बुलेटिन

नेपाल भौगर्भिक समाज

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BULLETIN
OF
NEPAL GEOLOGICAL SOCIETY

NEPAL GEOLOGICAL SOCIETY

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September 2013 – August 2015

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EDITORIAL

The Editorial Board is delighted to bring out the Volume 32 of Bulletin of Nepal Geological Society. This volume highlights the regular activities that the Society had performed since the publication of the previous volume. It also includes some scientific articles on various topics of geosciences and abstracts of the papers presented on IDDR Day -2014 and various other Scientific Talk Programmes organized by Nepal Geological Society.

We thank authors for contributing their valuable papers to this volume. Similarly, we thank all members of the Society for their continuous cooperation and participation in various activities organized by the Society. The Board also appreciates the help from the current executive committee of the Society. Finally, the Board, on behalf of the Nepal Geological Society, gratefully acknowledges the financial and technical supports from the consulting firms, agencies, and organizations.

We hope that the readers will find this volume useful and informative. We believe that the contents of the current volume are of great value to our readers. Comments and suggestions for further improvement of the Bulletin are highly welcomed.

Thank you!
–Editorial Board

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NGS NEWS

NEPAL GEOLOGICAL SOCIETY (NGS)

Nepal Geological Society is the professional umbrella of all geologists working in Nepal and outside of Nepal, has over 700 members among which more than 170 scientists are from foreign countries. The Society was established in 1980 with the aim of developing and promoting the research and application of geological sciences to the national development through fostering high professional standard among members; promoting and protecting the professional interests of earth scientist of the country and to play an active role in the protection and conservation of environment through reducing the natural disasters.

Since its establishment, the Society has been working towards the advancement of geosciences in Nepal and is playing a leading role towards building up consensus among the government and private sectors on the role of geosciences on the national development. The Society is organizing the international as well as national level seminars, workshop and frequent talk programs. The Journal of Nepal Geological Society is the only one scientific journal regularly published from Nepal that incorporates research findings focused to the Himalayan Regions in addition to its annual activites, The bulletin of the Society includes the articles that are more focused to the interest of general public.

Scientific Talk Programs, Workshops, Interactions & Geological Congress organized by NGS

S.N.	Date	Title	Speaker	Location	No. of Participation	Collaborating organization
1	August 13, 2014	Special Talk Program on Sunkoshi Landslide Damming: Causes, consequences and Actions	Prof. M. R. Dhital; S. C. Amatya; T. L. Adhikari; D. R. Pandey	Russian Center of Science and Culture, Kamalpokhari, Kathmandu	150	Nepal Landslide Society, Himalayan Landslide Society, Nepal Geotechnical Society and NSET-Nepal
2	July 18, 2014	Engineering Geology at the Boundary of Feasibility: Recent Case Histories	Dr. Ulrich Glawe	Saumil Party Palace, Sinamangal	100	Society of Transport Engineers-Nepal (SOTEN) and Full Bright Consultancy (FBC)
3	2071.3.20	Nutrient dynamics: Anthropogenic Alteration and Challenges	Dr. Dev Prasad Jaisi	Department of Mines and Geology, Auditorium Hall, Lainchaur	60	Department of Mines and Geology (DMG)
4		Glacier Status in Nepal and Decadal Change from 1980 to 2010	Mr. Samjwal Ratna Bajracharya	Elite Hall, Trade Tower, Thapathali	70	ICIMOD
5	2014 Oct. 28	IDDR Day	Paper Presented by Differnt Authors	Russian Center of Science and Culture, Kamalpokhari, Kathmandu	150	Russian Center of Science and Culture, Kamalpokhari, Kathmandu
5	2071 /01 / 26, Friday	Interaction program on Geoscience Teaching in Nepal: Opportunities and Challenges (नेपालमा भूगर्भशास्त्र शिक्षण: अवसर र चुनौति)	Interaction	Seminar Hall of Nepal Academy of Science and Technology (NAST), Khumaltar	35	Central Department of Geology, TU and NAST
6	April 10-11, 2014	Metamorphic Pressures, Temperatures and their tectonic significance: Methods and applications to the Himalaya	Professor Matthew J. Kohn	Department of Geology, Tri-Chandra Campus, Seminar Hall, Ghantaghar	70	Department of Geology, Trichandra Campus
7	April 7-9, 2015	7th Nepal Geological Congress	Paper Presented by National & International Authors	Hotel Yak & Yeti Kathmandu	200	

NGS NEWS

36th AGM Held

The 36th Annual General Body Meeting (AGM) of the Nepal Geological Society (NGS) was held in the auditorium hall of the Department of Mines and Geology (DMG), Lainchaur, Kathmandu on 12th September 2014 (B. S. 2071 Bhadra 27). President of the 16th Executive Committee Dr. Dinesh Pathak chaired the General Body Meeting. The meeting began with the welcome speech by Mr. Dinesh Napit, General Secretary, NGS. Mr. Napit presented the Annual Report to the General Body highlighting the various activities and events the 16th committee carried out in the last one year. Mr. Shiva Baskota, Treasurer, presented the Financial Report, including the Auditor's Report, for the Fiscal year 2069/070 B. S. Following the presentation of the General Secretary and Treasurer, a lively discussion session was held on various issues to address the question raised by NGS members in connection with the Annual and financial reports. After the discussion both the reports presented by the General Secretary and Treasurer were approved by the AGM. With the recommendation of the Executive Committee, the AGM decided to appoint Mr. Bhoj Raj Ghimire as new auditor for the year 2070/2071. More than 100 NGS members participated and discussed on various issues during the meeting.

IDDR Day-2014 Observed

Nepal Geological Society (NGS) is being a professional organization that is committed to work towards reducing hazard, vulnerability, and resulting disaster in the country. It has been working in disaster inventory, preparedness and advocacy since its establishment (last three decades). United Nation (UN) proclaimed the theme to celebrate disaster day 2014-2015 as: **"Older Persons and Disasters - Resilience is for Life"**. Giving high priority to this theme NGS organized a half-day workshop on October 28, 2014 in collaboration with Mitra Kunj, Russian Centre for Science and Culture and Himalayan Conservation Group. The program was inaugurated and addressed by Hon'ble Deputy Prime Minister and Minister of Home Affairs, Mr. Bam Dev Gautam. The program was also addressed by the distinguished guests present in the program. There were three thematic presentations, each followed by discussion over the queries of participants. The workshop was divided into two sessions namely Inauguration Session and Technical Session. There were more than 90 participants consisting of researchers, policy makers, representatives of organization working in the disaster sectors.

नयाँ वर्ष २०७२ सालको पावन अवसरमा नेपाल भौगर्भिक समाजका सदस्यज्यूहरू तथा सम्पूर्ण देशवासीलाई **मंगलमय शुभकामना** व्यक्त गर्दछौं ।

नेपाल भौगर्भिक समाज

36TH ANNUAL GENERAL BODY MEETING OF THE NEPAL GEOLOGICAL SOCIETY

12th September 2014 (27th Bhadra 2071)

नेपाल भौगर्भिक समाजको १६ औं कार्यकारिणी समितिका अध्यक्ष डा. दिनेश पाठकको साधारण सभामा व्यक्त मन्तव्य

समाजका सम्मानित सदस्य, पूर्व अध्यक्षज्यू तथा सम्पूर्ण सदस्य साथीहरू,

नेपाल भौगर्भिक समाजको ३६औं साधारण सभामा यहाँहरू सबैलाई हार्दिक स्वागत गर्न पाउँदा गौरवान्वित महसुस गरिरहेको छु। यहाँहरू सबैको प्रयास, सहयोग र सदभाबको कारण यस समाज पेशागत समाजहरूको बिचमा अग्रण स्थान बनाउन सफल भएको छ । यस स्थानलाई कायम नैं राखी अझै रचनात्मक सोंचका साथ कार्यक्रमहरू गर्दै अगाडी बढ्नु पर्ने दायित्वबोध प्रत्येक कार्यकारिणी समितिको लागि प्रमुख चुनौतिको बिषय बन्न पुग्दछ जुन यस समाजको गतिशिलता को परिचायक पनि हो ।

यहाँहरूले यस सोह्रौं कार्यकारी समितिलाई जिम्मेबारी सुम्पिनुभएको एक वर्षको अवधिमा हामीले समाज, भूबिज्ञान तथा समाजका सदस्यहरूको हितमा गरेका कार्यहरू यहाँहरूले प्रत्यक्षरूपमा अनुभूति गर्नुनै भएको छ भन्ने बिश्वास गरेका छौं । यसको बिष्तृत जानकारी महासचिबज्यू ले गराउनु नैं हुने छ । हाम्रा प्रयासहरूलाई बुँदागत रूपमा बर्गीकरण यस प्रकार गर्न सकिन्छ ।

- समाजका सदस्यहरूसँग निरन्तर रूपमा सम्पर्कमा रही समाजका कार्यक्रममा सदस्यहरूको सहभागिता बढाउनु
- कार्यक्रमहरू बिषयगतको साथै व्यबहारिक रूपमा उपयोगी विषयबस्तुको चयन र सोको लागि उपयुक्त प्रस्तोताको चयन
- अन्य पेशागत समाज, प्राज्ञिक संस्था, सरकारी संस्था तथा अन्तराष्ट्रिय गैर सरकारी संस्थासंगको सहकार्य
- हाम्रा भनाई तथा बिचारलाई भू-बिज्ञानसँग नजिक बिषयगत विज्ञहरूको बिचमा पुर्याउनको लागि हाम्रा कार्यक्रमहरूमा विभिन्न विधाका व्यक्तिहरू पनि सहभागी हुने वातावरण सिर्जना गर्नु
- समाजको तर्फवाट भू-विज्ञानको महत्व, हालको अवस्था तथा भू-वैज्ञानिकले दिनसक्ने योगदान लगायत सरकारी संरचनामा गर्न पर्ने परिवर्तन, भू-बैज्ञानिकको लागि पद सिर्जना गर्नु पर्ने आवश्यकता सम्बन्धि जानकारीमुलक लेख, टेलिविजन, रेडियो अन्तर्वार्ता मार्फत सम्बन्धित पक्षको ध्यान आकर्षण गर्ने पहल
- भौगर्भिक काउन्सिल को स्थापनार्थ आवश्यक पर्ने गृहकार्यको सुरुवातको रूपमा प्राज्ञिक क्षेत्रमा कार्यरत भू-बैज्ञानिकबिच अन्तक्रिया कार्यक्रम गरी सो मार्फत आवश्यक जानकारी संकलन गरियो आउँदा दिनमा सरकारी, अर्धसरकारी संस्थानमा कार्यरत भूबैज्ञानिक तथा निजि क्षेत्रमा कार्यरत भूबैज्ञानिकहरू संगको अन्तक्रिया कार्यक्रम आयोजना गरि यी सबैबाट संकलित जानकारिहको सारसंक्षेपबाट भौगर्भिक काउन्सिलको आवश्यकता दर्साउने दस्ताबेज तयार गरी सोको लागि आवश्यक कदम चाल्ने । यस कार्यको लागि आवश्यक पर्ने प्रशासनिक तथा राजनैतिक पहुँचको लागि सक्षम सदस्यको सहयोगको लागि म अनुरोध गर्न चाहन्छु ।

समाजले २०१५ अप्रिल ७/९ मा आयोजना गर्ने सातौं नेपाल भौगर्भिक कंग्रेस को लागि प्रा. डा. बिष्णु डंगोल को नेतृत्वमा आवश्यक कार्य अगाडी बडाईसकेको कुरा यहाँहरू सबैमा विदित नैं छ । समाजको उक्त महत्वपुर्ण गतिबिधि सफलतापुर्बक सम्पन्न गर्नको लागि विभिन्न समितिहरू मार्फत क्रियाशील भएर अथवा बाहिरबाट पनि सहयोग पुर्याउनुहुन सदस्य महानुभावहरूमा अनुरोध गर्दछु ।

नेपाल भौगर्भिक समाजले प्रत्येक बर्ष २ जना विज्ञहरूलाई प्रदान गर्न सक्ने सम्मानित सदस्यताको लागि उपयुक्त व्यक्तित्वको चयनको लागि सहयोग गर्न यस समाजका पूर्व अध्यक्ष श्री जगदिश्वर नाथ श्रेष्ठज्यू को संयोजकत्वमा गठन गरियको सिफारिस समितिले आवश्यक गृहकार्य गरी सिफारिस गरेको नामावली लाई कार्यकारी समितिले सहमति प्रदान गरि यस साधारण सभामा निर्णयार्थ राख्न गईरहेको छ । हामीलाई आशा छ भू-विज्ञान, नेपाल हिमालय तथा समाजको लागि महत्वपुर्ण योगदान दिनुहुने वहाँहरूको नामलाई यस सभाले सर्बसम्मती बाट स्विकृत गरि सम्मानित सदस्यहरूको सम्मानपूर्बक मनोनयन गर्ने हाम्रो गौरवमय परम्परालाई निरन्तरता दिनेछ । यस सम्मानको लागि थुप्रै व्यक्तित्वहरू योग्य हुँदाहुँदै पनि हामीले एकबर्षमा दुई जनालाई मात्र मनोनयन गर्न सक्ने अधिकार समाजको विधानले निर्धारित गरेको छ आउँदा बर्षहरूमा हामीले यो प्रक्रियालाई निरन्तरता दिदै क्रमिक रूपमा वहाँहरूको योगदानलाई सम्मान गर्ने प्रतिबध्दता व्यक्त गर्दछौ ।

गत वर्ष यस समाजले आयोजना गरेका विभिन्न कार्यक्रमहरूमा सहकार्य गर्ने निकायहरू जस्तैः भूगर्भशास्त्र केन्द्रिय बिभाग, किर्तिपुर, भूगर्भ बिभाग त्रिचन्द्र क्याम्पस, ICIMOD, नेपाल पहिरो समाज, हिमालयन पहिरो समाज, नेपाल जियोटेक्निकल समाज, भूकम्प प्रबिधि राष्ट्रिय समाजनेपाल, नेपाल विज्ञान तथा प्रबिधि प्रज्ञा प्रतिष्ठान, ट्रान्सपोर्ट इन्जिनियर्स समाज नेपाल, फुलब्राइट कन्सल्टेन्सी प्रा.लि. लाई समाजको तर्फबाट विशेष धन्यवाद व्यक्त गर्दछु, खानी तथा भूगर्भ विभागले निरन्तर

रूपमा समाजको कार्यालय संचालनको लागि र अन्य सहयोग गरिएकोमा समाज कृतज्ञ छ र भबिस्यमा पनि यस प्रकारको सहयोगको अपेक्षा गर्दछ।

१६औ कार्यकारी समितिको विभिन्न समितिहरूमा बसी सहयोग गर्नुहुने तथा समाजका बिभिन्न कार्यक्रमहरूलाई सफल बनाउन प्रत्यक्ष तथा अप्रत्यक्ष रूपमा सहयोग गर्नुहुने सबै सदस्य महानुभावहरू प्रति यस कार्यकारी समिति हार्दिक आभार व्यक्त गर्दछ।

अन्तमा सोहौं कार्यकारी समितिका सबै साथीहरूलाई समाजका हरेक कार्यमा सक्रियरूपमा क्रियाशील हुनुभएको मा मेरो व्यक्तिगत तर्फबाट धन्यवाद दिंदै आउंदा दिनमा अझै सक्रियातापुर्वक क्रियाशिल हुनुहुनेछ भन्ने बिश्वास व्यक्त गर्दछु ।

सम्पूर्ण सहभागी सदस्य महानुभाबहरूलाई यस साधारण सभामा फेरी पनि स्वागत गर्दै सक्रिय सहभागिताको लागी अनुरोध गर्दछु।

धन्यवाद !

२०७१ भाद्र २७

नेपाल भौगर्भिक समाजको १६ औं कार्यकारिणी समितिका महासचिव श्री दिनेश कुमार नापितको साधारण सभामा व्यक्त स्वागत भाषण

यस समहरोहका सभापति एवं समाजका अध्यक्ष ज्यू,
समाजका पूर्व अध्यक्ष ज्युहरू,
कार्यकारिणी समितिका सदस्यज्युहरू,
उपस्थित समाजका सम्पूर्ण सदस्यज्युहरू,

नेपाल भौगर्भिक समाजको ३६औ साधारण सभामा १६ औ कार्यकारिणीको बिगत एक बर्ष कार्य अवधिमा भए गरेका क्रियाकलाप यहाहरू समक्ष प्रस्तुत गर्न गइरहेको छु. समाजको गत बर्षको बिस्तृत क्रियाकलाप लगायत अन्य बिषयबस्तु समाबेश गरि नेपाल भौगर्भिक समाजको बुलेटिन भाग ३१ प्रकाशित भैसकेको र सो यहाहरूले प्राप्त गरिसक्नु भैसकेको छ. यहाँ म मुख्य क्रियाकलापहरूलाई संक्षिप्त रूपमा प्रस्तुत गर्न गइरहेको छु ।

१६ औ कार्यकारिणी समितिले आफ्नो कार्यभार सम्हाले लगत्तै संयुक्त राष्ट्र संघको "LIVING WITH DISABILITIES AND DISASTER" नारा रहेको IDDR DAY-2013 मनाएको थियो र यसको सन्दर्भमा OCTOBER, 2013 मा रुसी संस्कृतिक केन्द्रको सभा हलमा सो केन्द्र लगायत सिंचाइ बिभाग र जल उत्पन्न प्रकोप नियन्त्रण बिभागसंगको संयुक्त आयोजनामा एक दिने कार्यशाला आयोजना गरिएको थियो. यस कार्यक्रमको आयोजनको निम्ति समाजका बरिस्ठ सदस्य श्री सागर कुमार राई ज्युको संयोजकत्वमा ११ सदस्यीय आयोजक समिति गठन गरिएको थियो. सो कार्यक्रम को प्रमुख अतिथि श्री प्रताप कुमार पाठक, सचिव, सिचाई मन्त्रालय रहेनु भयको थियो . सो कार्यक्रममा श्री प्रदिप कुमार कोइराला, गृह मन्त्रालय, षणमुखेश चन्द्र अमात्य जल उत्पन्न प्रकोप नियन्त्रण बिभाग, अर्जुन तिमिल्सिना, प्रहरी उपरीक्षक, नेपाल प्रहरीस ओम पुन 'श्रमिक' महासचिव, नेपाल अपाङ्ग समाजहरू द्वारा ४ वटा कार्यपत्रहरू प्रस्तुत गरिएका थिए भने कार्यक्रममा बिभिन्न सरकारी एवं गैर सरकारी संस्था लगायत समाजका सदस्यहरू गरि जम्मा १०५ जनाको उपस्थिति रहेको थियो ।

समाजका सम्मानित सदस्य Prof. Patrik Li Fort, फ्रान्स को १३ फेब्रुअरी मा असामयिक निधन भएकोले २१ फेब्रुअरी २०१४ मा समाजद्वारा उहाप्रति श्रद्धाञ्जली अर्पण गर्न खानी तथा भूगर्भ विभागको सभाहलमा सोक सभाको आयोजन गरेको थियो ।

१० मार्च २०१४ मा भूगर्भ शास्त्र शिक्षण बिभाग, त्रिचन्द्र क्याम्पसमा SCIENTIC TALK PROGRAM आयोजना गरिएको थियो. यस कार्यक्रममा डा. अशोक सिग्देल द्वारा" Evolution of the fluvial systems and petrography of sedimentary rocks of the Miocene Siwalik Group, Karnali River section, Nepal Himalaya: implications for provenance, paleoclimate and Himalayan tectonics "बिषयक र डा. कमल राज रेग्मी द्वारा "Petrology and Geochemistry of the Tynong Province Granitoids, Lachlan Orogen, Australia" बिषयमा आ-आफ्नो प्रस्तुति प्रस्तुत गर्नु भयको थियो ।

अप्रिल १० र ११, २०१४ मा भूगर्भ शास्त्र शिक्षण बिभाग, त्रिचन्द्र क्याम्पस संगको संयुक्त आयोजनामा "Metamorphism and Geocronology : Application in the Himalayas "बिषयक दुई दिने कार्यशाला आयोजन गरिएको थियो. यस कार्यशालामा Dr. Matthew Kohn, Distinguished Professor, Boise State University, USA ले आफ्नो बिभिन्न प्रस्तुतिहरू प्रस्तुत गर्नु भयको थियो. सो कार्यक्रममा ३० जनाको सहभागिता रहेको थियो ।

मे ९, २०१४ मा नेपाल बिज्ञान तथा प्रबिधि प्रज्ञा प्रतिष्ठान (नास्ट) तथा भूगर्भ शास्त्र केन्द्रिय बिभाग संगको संयुक्त आयोजनामा "नेपालमा भूगर्भ शास्त्र शिक्षण अवसर र चुनौती "बिषयक एक दिने अन्तरक्रिया कार्यक्रम नास्टको सभाहलमा आयोजना गरिएको थियो. नेपाल भौगर्भिक समाजले आफ्नो सदस्यहरू कार्यरत प्राज्ञिक, सरकारी, गैरसरकारी तथा निजि क्षेत्रमा रहेको अवसर र चुनौती पहिचान गर्ने सन्दर्भमा पहिलो खुड्किलोको रूपमा प्राज्ञिक क्षेत्रबाट क्षेत्रगत समस्याको पहिचान गर्ने कार्यको सुरुवात गर्ने सोचका साथ् सो कार्यक्रम आयोजन गरेको थियो. उक्त कार्यक्रमको प्रमुख आतिथि प्रा.डा. श्री शुरेन्द्र राज काफ्ले, उपकुलपति, नेपाल बिज्ञान तथा प्रबिधि प्रज्ञा प्रतिष्ठान द्वारा कार्यक्रमको उदघाटन गरिएको थियो. कार्यक्रममा भूगर्भ शास्त्र केन्द्रिय शिक्षण बिभागका प्रमुख प्रा.डा. श्री लालु प्रसाद पौडेल, नेपाल बिज्ञान तथा प्रबिधि प्रज्ञा प्रतिष्ठानका सदस्य (सचिब प्रा.डा. श्री प्रकाश चन्द्र अधिकारी, समाजका पुर्व अध्यक्ष तथा नेपाल बिज्ञान तथा प्रबिधि प्रतिष्ठानका प्राज्ञ, प्रा.डा. श्री विशाल नाथ उप्रेती, बिज्ञान तथा प्रबिधि अध्ययन संकाय डीन तथा विशेष अतिथि श्री चिरिक शोभा ताम्राकार, लगायत प्राज्ञिक क्षेत्रमा कार्यरत ३० जना को उपस्थिति रहेको थियो ।

जुन २७, २०१४ मा ICIMOD संगको संयुक्त आयोजनामा World Trade Tower, थापाथली को सभाहलमा "Glacier Status in Nepal and Decadal Change from 1980 to 2010" बिषयक Special Talk Program आयोजन गरिएको थियो. यस कार्यक्रममा Mr. Samjwal Ratna Bajracharya, Remote Sensing Specialist, ICIMOD ले आफ्नो प्रस्तुति प्रस्तुत गर्नु भएको थियो । सो कार्यक्रम मा १०० जनाको सहभागिता रहेको थियो ।

जुलाई ४, २०१४ मा खानी तथा भूगर्भ विभागको सभाहलमा "Nutrient Dynamics: Anthropogenic alteration and challenges" बिषयक Scientific Talk Program आयोजन गरिएको थियो । यस कार्यक्रममा Dr. Deb Jaisi, Department of Plant and Soil Sciences, University of Delaware, USA ले आफ्नो प्रस्तुति प्रस्तुत गर्नु भएको थियो ।

जुलाई १८, २०१४ मा Society of Transport Engineers-Nepal and Full Bright Consultancy संगको संयुक्त आयोजनामा "Engineering Geology at the Boundary of Feasibility; Recent Case Historiesæ" laifos Special Talk Program आयोजन गरिएको थियो. यस कार्यशालामा Dr. Ulrich Glawe, Germany ले आफ्नो

प्रस्तुति प्रस्तुत गर्नु भएको थियो. सो कार्यक्रम मा १०० जनाको सहभागिता रहेको थियो ।

अगस्ट १३ र २०१४ मा Nepal Landslide Society, Himalayan Landslide Society, Nepal Geotechnical Society and NSET-Nepal संगको संयुक्त आयोजनामा रुसी संस्कृतिक केन्द्रको सभा हलमा "Sunkoshi Landslide Damming: Causes, Consequences and Actionsæ बिषयक कार्यशाला आयोजन गरिएको थियो. यस कार्यशालामा प्रा. डा. मेघ राज धिताल, श्री संमुखेष अमात्य, श्री टुक लाल अधिकारी र श्री डी. आर. पाण्डे ले आ-आफ्नो कार्यपत्र प्रस्तुत गर्नु भएको थियो. सो कार्यक्रममा १०० जनाको सहभागिता रहेको थियो ।

यस समाजलाई नेपालमा भूगर्भ शास्त्र विज्ञानको अध्ययन, अनुसन्धान एवं प्रवर्धनको क्षेत्रमा उल्लेखनीय योगदान पुर्याए बापत प्रज्ञा प्रतिष्ठान विज्ञान तथा प्रविधि प्रवर्धन पुरस्कार, २०६९ र ७० सालको लागि नास्ट द्वारा प्रदान गरिएको पुरस्कार समाजका अध्क्षय उपस्थित हुनुभई प्राप्त गरिएको छ. टोनी हेगनकी छोरीहरूको सहयोगमा उहाद्वारा लेखिएको "Report on the Geological Survey of Nepal, Volume 2: Geology of the Thakkholaæ लाई पुस्न प्रकाशित गरिएको छ. ।

डा. दण्डपाणी अधिकारी ज्यू को नेतृत्वमा ११ सदस्यीय Editorial Boad को गठन गरिएको छ. कार्यकारिणी समितिमा ४ जना सदस्यहरू, डा. कमलाकान्ता आचार्य, डा. ज्ञानेन्द्र गुरुङ, श्री सुरेन्द्र शाह, र तारा पोखेल को मनोनयन गरिएको थियो ।

विभिन्न उपसमितिहरूको गठन गरिएको छ. सम्जोल रत्न बज्राचार्य को संयोजकत्वमा १३ सदस्यीय Scientitic उप(समिति, १४ सदस्यीय Council Formation and Professinal Development उप-समिति, समाजका सम्पूर्ण पूर्व अध्यक्षहरू एवं. राष्ट्रिय योजना आयोगका पूर्व अध्यक्ष तथा समाजका आजीवन श्री दिनेश चन्द्र देवकोटा रहेको १३ सदस्यीय सल्लाहाकार समिति, अन्तरास्ट्रिय प्रतिनिधि (डा. टेक प्रसाद ओझा, GSA; श्री अर्जुन अर्याल, अमेरिका, डा. कृष्ण चन्द्र देवकोटा , थाईल्याण्डस, डा. कृष्ण पन्थी, नर्वे, श्री बिरेन्द्र पिया, क्यानाडास डा. गणेश राज जोशी (जापान) मा मनोनयन गरिएको छ ।

७ - ९, अप्रिल २०१५ मा "7th Nepal Geological Congress" आयोजना गर्ने निर्णय गरिएको छ. यसको लागी प्रा.डा. बिष्णु डंगोल लाई Convenor र श्री राजेन्द्र खनाल लाई co-convenor को जिम्मेवारी प्रदान गरिएको छ. कंग्रेस आयोजा गर्ने सम्बन्धमा कांग्रेसको मिति तय, main theme, sub-themes, रजिस्ट्रेशन शुल्क, स्थलगत भ्रमण आदिको बारेमा यकिन गर्न समाजका बरिष्ठ सदस्यहरू संग पेट्रोलियम परियोजनाको सभा कक्षमा बिभिन्न मितिहरूमा दुई चरणको अन्तरक्रिया सम्पन्न गरिएको छ ।

खानी तथा खनिज उद्धयोग सम्बन्धि कार्यशाला आयोजना गर्न समाजका पूर्व अध्यक्ष श्री जगदिश्वर नाथ श्रेष्ठलाई संयोजक को जिम्मेवारी प्रदान गरिएको छ. यो कार्यक्रम खनिज क्षेत्र सम्बन्धित अन्य सरकारी र गैर सरकारी संघ संस्थाको सहकार्यमा गर्ने सोचाई रहेको र यसै सम्बन्धमा खानी तथा भूगर्भ बिभाग, नेपाल सिमेन्ट संघ, सुन चादी आभूषण तथा रत्न महासंघ, नेपाल क्रसर तथा खानी उद्योग महासंघ संग एक चरणको छलफल सम्पन्न भै सकेको छ ।

समाजद्वारा सम्मानित सदस्यता प्रदान गर्नको लागि सदस्यहरूको छनौट गर्नेको लागि समाजका पूर्व अध्यक्ष श्री जगदिश्वर नाथ श्रेष्ठ संयोजक रहेको तथा डा. सुरेश दास श्रेष्ठ र श्री लिला नाथ रिमाल सदस्य रहेको समिति लाई जिम्मेवारी प्रदान गरिएको छ ।

समाजका कोषाध्यक्ष श्री कुमार के.सी. द्वारा दिनुभएको राजिनामा स्वीकृत गरिएको र कार्यबाहक कोषाध्यक्षको जिम्मेवारी कार्यकारिणी समितिका सदस्य श्री शिव बास्कोटालाई दिएएको छ. यसै गरि डा. ज्ञानेन्द्र गुरुङको कार्यकारिणी समितिको सदस्यता खारेज गरिएको र रिक्त हुन् आएका सदस्यहरूमा श्री विश्व सिलवाल र श्री नरेश महर्जन लाई मनोनयन गरिएको छ ।

नेपाल भौगर्भिक समाजको नया web site निर्माण गरि संचालनमा ल्याईएको छ. धभद कष्तभ निर्माण र संचालन को जिम्मा Bent Ray Tech, Jwagal लाई दियिएको छ. यसरि संस्थागत रूपमा जिम्मेवारी प्रदान हुदा आगामी दिनमा समाजको web site लाई चुस्त र दुरुस्त राख्न मद्दत पुग्ने बिश्वास लिएका छौ ।

भूगर्भ शास्त्र केन्द्रिय शिक्षण बिभागको सिफारिसमा मित्र राई छात्रवृत्ति एम. एस्सी., भूगर्भशास्त्र दोश्रो वर्षा मा अध्यनरत श्री प्रकाश पोखेल, र सुश्री सिर्जना पौडेल लाई प्रदान गर्ने निर्णय गरिएको छ ।

समाजको ३५ औ साधारण सभामा नया लेखापरिक्षकको प्रस्ताब नगरिएकोले सो सभालेले यस कार्यकारिणी समितिलाई प्रदान गरेको अधिकार वमोजिम यस कार्यकारिणी समितिको कार्यकाल सम्मको लागि श्री भोज राज घिमिरे लाई लेखापरिक्षकको रूपमा नियुक्त गरिएको छ ।

सरकारी एवं गैर सरकारी संस्था (गृह मन्त्रालय, सहरी विकास तथा भवन निर्माण बिभाग, NSET, DPNET आदि) हरूद्वारा आमन्त्रित कार्यक्रममा कार्यकारिणी समितिका सदस्यहरू तथा अन्य समाजका सदस्यहरू लाई प्रतिनिधित्व गराई भाग लिने गरिएको छ ।

अन्त्यमा, समाजको कार्यमा निरन्तर सहयोग र साथ् प्रदान गरिदिनु भएकोमा सम्पूर्ण सदस्यहरू लगायत सम्पूर्ण निकायहरू प्रति आभार र धन्यवाद प्रदान गर्दै आगामी दिनहरूमा पनि यसको निरन्तरताको अपेक्षा राख्दै यो बार्षिक प्रतिबेदनको प्रस्तुति यहि टुंग्याउने अनुमति चाहन्छु ।

धन्यवाद !

दिनेश कुमार नापित

महासचिव

36TH ANNUAL GENERAL BODY MEETING OF THE NEPAL GEOLOGICAL SOCIETY

Auditor's Financial Report (FY 2070/71 B.S.)

BHOJ RAJ GHIMIRE
Sanogaucharan, Kathmandu
Registered Auditor
ICAN, COP No: -"GA"-559

Auditor's Report to the Members of
Nepal Geological Society
For the financial year 2070-071

We have audited attached Balance Sheet of Nepal Geological Society as on Ashad 32,2071 , Income & Expenditure account for the period 2070,Shrawan-1 to Ashad, 32, 2071 and report that:

1) We have obtained prompt replies to our queries including a satisfactory explanation during the course of the audit.
2) In our opinion, the organization has maintained proper books of account as require by law.
3) The Balance Sheet and Income & Expenditure account dealt with by the report are agreeing with the books of accounts maintained by the organization.
4) It has not come to our notice that any act done deliberately or otherwise the executive body or any employee of the organization in violation of law.
5) In our opinion and to the best of our information and according to the explanation given to us the said account have been correctly drawn up so as to reflect a true and fair view.

   a) In the case of the Balance Sheet, of the state of affairs of the organization as on Ashad 32, 2071
   b) In the case of Income Statement of the profit (Excess of Expenditure over the Income) for the period covering from 2070,Shrawan-1 to Ashad 32, 2071.

Date: - 2071, Bhadra-16
Place: -Kathmandu

BHOJ RAJ GHIMIRE
Registered Auditor

36TH ANNUAL GENERAL BODY MEETING OF THE NEPAL GEOLOGICAL SOCIETY

Auditor's Financial Report (FY 2070/71 B.S.)

Nepal Geological Society
Kathmandu
Balance-Sheet
As of July 16, 2014

Particulars	Sch.	Current Year (Rs.)	Previous Year (Rs.)
Liabilities:			
Surplus/(Deficit) Fund	1	4,896,313.73	5,161,615.38
Payable	2	231,229.55	238,927.55
Total		**5,127,543.28**	**5,400,542.93**
Assets:			
Bank Balance	3	5,083,601.28	5,377,810.84
Account Receivable	4	43,942.00	22,732.09
Deposit		-	-
Total		**5,127,543.28**	**5,400,542.93**

Schedule 1 to 6 form integral part of the financial statements

President

General Secretary

Treasure

Bhoj Raj Ghimire
Registered Auditor

36TH ANNUAL GENERAL BODY MEETING OF THE NEPAL GEOLOGICAL SOCIETY

Auditor's Financial Report (FY 2070/71 B.S.)

Nepal Geological Society
Kathmandu
Income and Expenditures Accounts
For the period from July 16, 2013 to July 16, 2014

Particulars	Sch.	Current Year (Rs.)	Previous Year (Rs.)
Income:	5	895,614.00	9,370,594.48
Interest received		27,082.17	10,007.28
Total-A		**922,696.17**	**9,380,601.76**
Expenses :			
Program Activities		-	-
Office Operating cost	6	1,187,997.82	7,083,851.40
Total-B		**1,187,997.82**	**7,083,851.40**
Surplus/(Deficit) C= (A - B)		**(265,301.65)**	**2,296,750.36**

Schedule 1 to 6 form integral part of the financial statements

President

General Secretary

Treasure

Bhoj Raj Ghimire
Registered Auditor

नेपाल भौगर्भिक समाज NEPAL GEOLOGICAL SOCIETY 2037 काठमाडौं

36TH ANNUAL GENERAL BODY MEETING OF THE NEPAL GEOLOGICAL SOCIETY

Auditor's Financial Report (FY 2065/66 B.S.)

Nepal Geological Society

Kathmandu

Cash Flow Statement for the Year Ended Ashadh 32,2071

Particulars	Schedule	Amount
A) Cash From Operational Activities		
Surplus(Deficit)		(265,301.65)
Cash Flow Prior to Change in Working Capital		
Change in Working Capital		**(265,301.65)**
Increase(Decrease) in Current Liabilities		(7,698.00)
Decrease(Increase) in Current Assets		(21,209.91)
Net Change in Working Capital		**(294,209.56)**
Net Cash Flow From Operation		**(294,209.56)**
B) Cash Flow from Investment		
Sale/ (Purchase) of fixed Assets		-
Net Cash Flow from Investment		-
C) Cash Flow from financing		
Life Membership Fee		-
Net Cash Flow from Financing		-
Net Cash Flow		**(294,209.56)**
Opening Cash & Bank Balance		
Cash balance	-	
Bank balance		5,377,810.84
Cash balance	-	
Bank balance	5,083,601.28	
Closing Cash and Bank balance	**5,083,601.28**	**5,083,601.28**

President

General Secretary

Treasurer

Bhoj Raj Ghimire
Registered Auditor

Nepal Geological Society
Kathmandu
Schedules for FY-2070/71

Schedule -1		
Particulars	**Current year (Rs.)**	**Previous year (Rs.)**
Surplus Fund:		
Up to last year	5,161,615.38	2,864,865.02
Addition during this year	(265,301.65)	2,296,750.36
Total	**4,896,313.73**	**5,161,615.38**

Schedule -2		
Particulars	**Current year (Rs.)**	**Previous year (Rs.)**
Payable:		
TDS Audit Fee	2,735.00	1,235.00
Other Payable-USD2403.29	228,312.55	228,312.55
TDS-Spectrum Advertisement	182.00	-
Advance -R.P. Ghimire	-	9,380.00
Total	**231,229.55**	**238,927.55**

Schedule -3		
Particulars	**Current year (Rs.)**	**Previous year (Rs.)**
Cash & Bank Balance:		
NABIL Bank-Current Account	431,446.06	993,127.89
NABIL Bank-Current Account(USD)-$44731.92	4,249,532.40	4,239,082.40
Nepal Bank Limited-Current Account	9,949.68	9,949.68
Agriculture Development Bank-Saving Account	77,072.80	74,908.43
Nepal Bank Limited-Saving Account	60,075.44	60,075.44
Rastriya Banijya Bank-Current Account	15,524.90	-
Rastriya Banijya Bank-Term Deposit	240,000.00	-
Cash Balance	-	667.00
		-
Total	**5,083,601.28**	**5,377,810.84**

Schedule -4		
Particulars	**Current year (Rs.)**	**Previous year (Rs.)**
Account Receivable		
Account Receivable	-	1,200.00
Advance-Dinesh	-	700.00
TDS	-	4,832.09
Advance	-	10,000.00
B/R	-	6,000.00
DP Adhikari (Advance)	25,000.00	-
Advance -R.P. Ghimire	15,000.00	-
Petty cash-Siva Baskota	3,942.00	-
Total	**43,942.00**	**22,732.09**

Nepal Geological Society
Kathmandu
Schedules for FY-2070/71

Schedule -5		
Particulars	Current year (Rs.)	Previous year (Rs.)
Income:		
Registration	-	6,229,051.75
Sales of Books & Journal	168,515.00	153,364.08
Contribution	321,580.00	2,883,849.65
Advertisement on Journal	125,000.00	79,629.00
Membership Fee	182,069.00	24,200.00
Entrance Fee	4,300.00	500.00
Contribution for Dinner	43,300.00	-
Income for Seminar	50,000.00	-
Other Income	850.00	-
Total	895,614.00	9,370,594.48

Schedule -6		
Particulars	Current year (Rs.)	Previous year (Rs.)
Office Operating Cost:		
Journal publish	313,861.52	-
Books	342,950.00	-
AGM Expenses	250,327.00	-
Talk Programme Expenses	75,216.65	-
Hospitality	64,395.95	36,905.00
Notice Publication	31,019.00	-
Telephone & Internet	17,000.00	19,373.00
Stationary	15,272.00	76,995.00
Election exp	14,915.00	-
Batch	12,800.00	-
Audit Fee	10,000.00	8,235.00
Misc. Office Cost	11,043.44	24,327.00
Souvenir	8,750.00	-
Wages	8,500.00	49,900.00
Printing	3,573.00	891,461.98
Web Hosting	3,390.00	-
Transportation	2,860.00	10,490.00
Registration & Renewal	1,500.00	7,010.00
Bank Charge	500.00	24,092.35
Exchange Loss	124.26	195,758.07
Advertisement	-	33,554.00
Office Equipment	-	158,000.00
Postage	-	8,800.00
Repair & Maintenance	-	1,200.00
Seminar & Meeting	-	78,550.00
Computer and Accessories	-	8,500.00
Designing & Editorial Cost	-	161,165.00
Electrical Work	-	68,273.00
Excursion	-	1,376,293.00
HKT	-	3,844,969.00
Total	1,187,997.82	7,083,851.40

LIST OF COMMITTEES

16th Executive Committee

The 16th executives elected for the two years starting from September 1st 2013 to August 31st 2015 are:

Dr. Dinesh Pathak	President
Mr. Sudhir Rajaure	Vice President
Mr. Dinesh Kumar Napit	General Secretary
Mr. Sunil Raj Poudel	Deputy General Secretary
Mr. Kumar K.C.	Treasurer
Mr. Uttam Bol Shrestha	Member
Mr. Shiva Kumar Baskota	Member
Mr. Narayan Banskota	Member
Mr. Umesh Chandra Bhusal	Member
Mr. Surendra Shah	Member
Dr. Kamalakanta Acharya	Member
Ms. Tara Pokhrel	Member
Dr. Gyanendra Gurung	Member

The 16th Executive Committee formed Editorial Board of the Journal of Nepal Geological Society and several other committees, sub-committees and representatives as below to support its activities:

Editorial Board of the Journal of Nepal Geological Society

Dr. Danda Pani Adhikari	Editor-In-Chief
Dr. Beth Pratt Sitaula	Member
Dr. Tetsuya Sakai	Member
Mr. Jayendra Man Tamrakar	Member
Mr. Mukunda Raj Poudel	Member
Mr. Surendra Raj Shrestha	Member
Dr. Prem Bahadur Thapa	Member
Dr. Ghanashyam Neupane	Member
Dr. Subesh Ghimire	Member
Dr. Sunil Kumar Dwivedi	Member
Dr. Ganesh Nath Tripathi	Member

Advisiory Committee

Mr. Jhumar Mal Tater	Ex-President, NGS
Mr. Gopal Singh Thapa	Ex-President, NGS
Mr. Nirendar Dhoj Maskey	Ex-President, NGS
Mr. Narendra Bahadur Kayastha	Ex-President, NGS
Mr. Vinod Singh Chettri	Ex-President, NGS
Dr. Ramesh Prasad Bashyal	Ex-President, NGS
Mr. Achyuta Nanda Bhandary	Ex-President, NGS
Dr. Amod Mani Dixit	Ex-President, NGS
Mr. Krishan Prasad Kaphle	Ex-President, NGS
Prof. Dr. Bishal Nath Upreti	Ex-President, NGS
Mr. Ramesh Kumar Aryal	Ex-President, NGS
Mr. Pratap Singh Tater	Ex-President, NGS
Dr. Ramesh Man Tuladhar	Ex-President, NGS
Prof. Dr. Megh Raj Dhital	Ex-President, NGS
Mr. Jagadiswar Nath Shrestha	Ex-President, NGS
Mr. Uttam Bol Shrestha	Ex-President, NGS
Dr. Dinesh Chandra Devkota	Ex- Vice-Chair, NPC

IDDR Day Organizing Committee

Mr. Sagar Kumar Rai	Coordinator
Mr. Andy Prakash Bhatta	Co-Coordinator
Mr. Shanmukhesh Chandra Amatya	Member
Mr. Churna Bahadur Oli	Member
Mr. Sunil Shrestha	Member
Mr. Dinesh Nepali	Member
Dr. Subesh Ghimire	Member
Mr. Ajaya Raj Adhikari	Member
Ms. Pramila Shrestha	Member
Ms. Shailina Manandhar	Member
Mr. Dinesh Kumar Napit	Member

Scientific Sub-committee

Mr. Samjwal Ratna Bajracharya	Coordinator
Dr. Suresh Das Shrestha	Member
Prof. Dr. Lalu Prasad Poudel	Member
Dr. Tara Nidhi Bhattarai	Member
Dr. Naresh Kaji Tamrakar	Member
Mr. Lila Nath Rimal	Member
Dr. Prakash Das Ulak	Member
Mr. Subash Chandra Sunuwar	Member
Dr. Basanta Raj Adhikari	Member
Dr. Kamal Raj Regmi	Member
Dr. Ashok Sigdel	Member
Mr. Sudan Bikash Maharjan	Member
Mr. Sudhir Rajaure	Member

Geological Council Formation and Professional Development Sub-Committee

Dr. Dinesh Pathak	Coordinator
Mr. Krishna Prasad Kaphle	Members
Mr. Moti Bahadur Kunwar	Members

Mr. Pratap Singh Tater	Members
Prof. Dr. Bishal Nath Upreti	Members
Mr. Jagadishwar Nath Shrestha	Members
Dr. Amod Mani Dixit	Members
Mr. Dinesh Kumar Napit	Members
Mr. Sagar Kumar Rai	Members
Mr. Sarbjit Prasad Mahato	Members
Mr. Gopal Singh Thapa	Members
Dr. Dinesh Chandra Devkota	Members
Prof. Dr. Lalu Prasad Paudel	Members
Mr. Durga Prasad Osti	Members

International Representatives

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kesandevkota@gmail.com

International Day for Disaster Reduction IDDR-Day 2014
"Older Persons and Disasters - Resilience is for Life"

Workshop organized by:

Nepal Geological Society
in association with

Mitra Kunj, Russian Centre of Science and Culture and Himalaya Conservation Group

Kathmandu, Nepal

October 28, 2014

PROGRAM

Venue: Russian Centre for Science & Culture, Kamalpokhari, Kathmandu, Nepal

Session	Time	Activities
Session 1: Program Inauguration	09:30 - 10:00	Registration of Participants
	10:00- 10:05	Chairing of Session
	10:05 - 10:10	Welcome Speech by Mr. Sagar Kumar Rai, Convener, IDDR Organizing Committee
	10:10- 10:15	Workshop Inauguration by **Chief Guest The Hon'ble Deputy Prime Minister and Minister-MoHA - Bam Dev Gautam**
	10:15 - 10:20	Speech by Mr. C. K. Acharya. President Mitra Kunj
	10:20 - 10:25	Speech by Mr. Anton Maslov, Deputy Director, Russian Centre of Science and Culture
	10:25 - 10:35	Speech by Mr. Ganga Lal Tuladhar, Former Minister and Chairman, Himalaya Conservation Group
	10:35 - 10:50	Speech by **Chief Guest**
	10:50 - 10:55	Speech by NGS President, Dr. Dinesh Pathak
	10:55 - 11:00	Vote of Thanks by NGS General Secretary Mr. Dinesh Napit
Session 2: Technical Paper Presentation	**Chairman: Mr. Krishna Prasad Kaphle, Former President, NGS** **Rapporteurs: Mr. Roshan Raj Bhattarai and Krishna Kumar Shrestha**	
	11:10 - 11:35	**Safety of Senior Citizens during Earthquakes** *Mr. Bijay Krishna Upadhyay, NSET*
	11:35 - 12:00	**Older people and management of geodisasters in Nepal** *Dr. Ranjan Kumar Dahal, Tri-Chandra Campus, Tribhuvan University*
	12:00 - 12:25	**Psycho-Social Issues of Older People** *Ms. Jaya Shilpakar and Mr. Sulav Raj Upreti, Researcher*
Closing	12:25 - 12:30	Wrap Up by Chairman
12:30 - 13:00 : Lunch		

IDDR Workshop Report-2014

International Day for Disaster Reduction IDDR-Day 2014

"Older Persons and Disasters - Resilience is for Life"

NGS AND DISASTER RISK REDUCTION ACTIVITIES

The geological disaster (landslide, flood, earthquake) are the major threat to the national development and poverty alleviation in Nepal. Therefore, Nepal Geological Society initiated the advocacy in the area that included awareness campaign through the regular celebration of the International Day for Natural Disaster Reduction (UN/IDNDR) since 1990s, occasional publication of disaster-related booklets etc. Likewise, after the establishment of UN ISDR (United Nation International Strategy for Disaster Reduction), the Society has carried its activities in line with the UN/ISDR aims of building disaster resilient communities by promoting increased awareness of the importance of disaster reduction for reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental disasters.

The activities of NGS towards Disaster Prevention was acknowledged by UN Humanitarian and Emergency Relief Co-ordination Office of IDNDR Secretariat in Geneva, by awarding UN-Sasakawa Disaster Prevention Award in 1998 for its efforts in disseminating the scientific knowledge and spreading the awareness of prevention of the natural disaster.

Nepal Geological Society is committed to continue to advocate for disaster risk reduction and mitigation activities in the country. This professional organization is always open to have partnership with other national and international organizations involved in this sector.

THE IDDR-DAY 2014

Nepal Geological Society (NGS) is a professional organization that is committed to work towards reducing hazard, vulnerability, and resulting disaster in the country. It has been working in disaster inventory, preparedness and advocacy since its establishment (last three decades). United Nation (UN) proclaimed the theme to celebrate disaster day 2014 as: "**Older Persons and Disasters - Resilience is for Life**". Giving high priority to this theme NGS organized a half day workshop on October 28, 2014 in collaboration with Mitra Kunj, Russian Centre for Science and Culture and Himalaya Conservation Group.

The program was organized in the Russian Culture Center hall, Kamal Pokhari, Kathmandu. There were more than 90 participats consisting of researchers, policy makers and practitioner representing various organizations working in the disaster sectors. The program was inaugurated and addressed by **Hon'ble Deputy Prime Minister and Minister of Home Affairs, Mr. Bam Dev Gautam**. The program was also addressed by the distinguished guests. There were three thematic presentations, each followed by discussion over the queries of participants. The workshop was divided into two sessions namely Inauguration Session and Technical Session.

INAUGURAL SESSION

The session was chaired by Dr. Dinesh Pathak, President of NGS and the program was inaugurated by **Hon'ble Bam Dev Gautam**, Deputy Prime Minister and Minister of Home Affairs, Government of Nepal. The speakers in the inauguration session were Hon'ble Bam Dev Gautam; Dr. Dinesh Pathak, President-Nepal Geological Society; Mr. Sagar Kumar Rai, Convener, NGS-IDDR-2014; Mr. Chandra Kant Acharya,

President-Mitra Kunj; Mr. Anton Maslov, Deputy Director-Russian Centre of Science and Culture and Mr. Ganga Lal Tuladhar, Former Education Minister and Chairman- Himalaya Conservation Group. All the speakers focused on the role of professional society and disaster risk reduction as well as the themes of UN/ISDR. Mr. Dinesh Napit, General Secretary-NGS delivered vote of thanks.

Mr. Sagar Kumar Rai, Convener of the NGS-IDDR Committee delivered welcome speech on behalf of the organizing committee. Mr. Rai welcomed all the guests, resource persons and participants in the workshop. In his

welcome speech Mr. Rai shaded light on the main objectives of the workshop focusing on the theme given by the UN for this year "*Older Persons and Disasters - Resilience is for Life*". He also reiterated that Nepal Geological society has long been recognized for research initiatives, regular publication, and organization of national / international seminar workshop and has contributed in development and disaster mitigation endeavors. He stressed on the relevancy of the theme in view of the necessity to focus our disaster risk reduction activities to the older persons.

Mr. Rai mentioned that ISDR Day has been observed by NGS since long, specially focusing on interactive workshop and seminar with view to share the knowledge and practices of disaster management and to generate awareness among the stakeholders. In addition, he mentioned that the invited papers from academia, researcher and practitioner are equally important issues to be covered for the disaster management. He believed that at the end of the workshop NGS will be able to produce a report with assessment of our present capacity, identifying substantial activities to be done and practical recommendations to the Govt. and policy makers.

Mr. Chandra Kant Acharya, President, Mitra Kunj highlighted on the contribution of the members of Mitra Kunj who are graduated from Russia (formerly Soviet Union). He mentioned that the members are from various fields and contributing to national development for longer time. He also took some examples of people involved in disaster risk reduction activities through various government, non-government and professional organizations as well as academia. He thanked NGS for continued collaboration on the IDDR Day celebration.

Mr. Anton Maslov, Deputy Director, Deputy Director, Russian center of Science and Culture, appreciated the continuous attachment of Nepal Geological Society with the Russian Centre of Science and Culture for the celebration of IDDR Day. He recalled the last year's program with the theme

of 'Disaster and disabled" and wished fruitful discussion on this year's theme "Disaster and Older Persons".

Mr. Ganga Lal Tuladhar, Chairman, Himalayan Conservation Group and Former Education Minister, said that

this year's IDDR Day theme is highly relevant in Nepalese context as there is no visible approach to make them involve in disaster risk reduction activities and also effective social security to the older persons. He himself being a researcher in the field of disaster management, stressed the need to make our communities more disaster resilient. He also wished for the success of the workshop and expected strong suggestion and recommendation from this workshop to the policy makers and the implementers.

Hon'ble Bam Dev Gautam, Deputy Prime Minister and Minister of Home Affairs, as well as the **Chief Guest** of the function, this year's IDDR Day theme is highly relevant in Nepalese context. He mentioned the need of formulation of new and review of the existing disaster related government policies and laws considering the situation of people living with

disabilities. He also wished for the success of the workshop and expected strong suggestion and recommendation from this workshop to the policy makers and the implementers.

Dr. Dinesh Pathak, Chairman of the session and President of Nepal Geological Society thanked the participants for their presence in spite of their busy schedule. He stressed that Nepal is geologically situated in a zone that is vulnerable to natural disaster. Because of this reason, Nepal Geological Society has been celebrating IDNDR and IDDR Day in cooperation with the concerned government and non-government organization so as to disseminate the information about disaster to the

general public. The Society is still committed to its objective towards disaster risk reduction and has been continuously involved in various related activities.

Dr. Pathak mentioned that according to Global Age Watch Index published by HelpAge International in October 2014, Nepal stands 70th position out of 96 countries. Dr. Pathak stressed the need of involving the older persons during the preparation of disaster management plan so that their long and valuable experiences could be shared and their issues could be well addressed in the plan. He mentioned that, in view of geographical and geological condition, Nepal is prone to hit by disaster and have experiences several such incidents in the past. In this context, NGS has organized this workshop in order to discuss the role of older people in disaster management and also to explore the ways how they can be helped during the disaster.

President Pathak highlighted the importance of geology in disaster mitigation. He also stressed that various branches of geosciences can play specific role in specific areas and hence it is urgent to for geological council so as to regulate, monitor and safeguard their role in various activities in the country and seek government support in this endeavor of the Society. He also acknowledged the partnership between Nepal Geological Society, Government bodies, local governments as well as Mitra Kunj, Russian Center of Science and Culture and Himalaya Conservation Group.

Mr. D. K. Napit, General Secretary, Nepal Geological Society, presented the vote of thanks. He thanked the Chief Guest, other guests, participants and collaborative organizations for their support and participation in the ISDR Day organized by the Nepal Geological Society.

TECHNICAL SESSION

The technical session was chaired by Mr. Krishna Prasad Kaphle, Former President, Nepal Geological Society. The reporters were Mr. Krishna Kumar Shrestha and Mr. Roshan Raj Bhattarai.

In this session three technical papers entitled (1) *Safety of senior citizens during earthquakes* by Mr. Bijay Krishna Upadhyay from Nepalese Society of Earthquake Technology (NSET); (2) *Older people and management of geo-disasters in Nepal* by Dr. Ranjan Kumar Dahal from Tri-Chandra Campus/ TU and (3) *Psycho-Social issues of older*

people by Ms. Jaya Silpakar and Sulav R. Upreti, researchers from Central Department of Psychology, TU.

The first speaker, Mr. Bijaya K. Upadhyay during his presentation, first of all mentioned that in Nepal there are just over 12,00,000 senior citizens (above 65 year old). Only very few of them (<0.1%) are residing in old shelter home (Briddhahram) in different parts of the country. His team from NSET visited one of the well known and largest Briddhashram in Pashupati area and surveyed the condition of the buildings, provided facilities like shelter, food, clothes, health services, security etc.) and also did interaction with the settlers about their feelings to be in Briddhashram. The audiovisual (slide/ photographs) of the home, bed room, kitchen, corridor, staircases, present condition of the building and provided facilities as well as interaction with them were also shown

during presentation. After the survey the team came into conclusion that many senior citizens residing over there are fairly happy. Most of them do not have formal education but have many experiences of some disasters including 1934 earthquake, landslide, flood etc. Almost all of them believe that all such disasters happened once the God got angry with the people and their mischievous activities. Many of them forget the information provided to day by next day due to their poor memory. The condition of the old building clearly shows that the residents in the building are vulnerable to earthquake. The narrow passages between beds and staircases are not suitable at all for their day to day movement, take wheel chairs around and go out in case of emergency situation due to fire or earthquake. 230 people are looking after only by 14 people (in fact 8 – 10 people daily). During interaction Mr. Upadhayay came to know that there is a plan to shift these people in a new place where earthquake resistance building with more facilities to the older people will be provided to make them comfortable.

Dr. Ranjan K. Dahal was the second speaker in the Technical Session of the Workshop. While presenting his

paper entitled "Older people and management of geo-disasters in Nepal", in the very beginning, he has highlighted on the potential Natural disasters specifically on landslide with the help of audiovisual. He had presented many examples like: landslide of Dharan – Dhankuta road, recent Jure Landslide in Sindhupalchok, landslide of Lamjung, landslide dam in Khimti Khola, Patukhola floodplain and haphazard development of Tulsipur town, Armala sinkhole in Pokhara, tall sandwitched building construction in Kathmandu etc. His presented data envisaged that in most of the cases old people, children and women are the main victims from such disaster (example: the number of old people killed in Sarlahi during 1934 earthquake, in recent Jure landslide etc.). Old people are the vulnerable ones and always remained at high risk. He has also given the example of involvement of old people in preparation of Disaster Management Plan in Japan and Philippines to minimize the risk, damage and loss of lives during disaster and advised for inclusion of older experienced people during formulation of such plan. He stressed on necessity to make aware of the people and develop early warning system. At the end, his presentation was focused on the risk of high rise buildings and 4 - 5 stories buildings constructed in different parts of Kathmandu valley. He concluded showing some

slides explaining very poor structural design saying "Where is national building code? Yahan ghar banune kam nabhayera ghar ropne kam bhayeko chha".

The third paper was presented by Ms. Jaya Shilpkar and Mr. Sulav R. Upreti on "Psycho-Social issues of Older people". The paper was based on the research carried out in old people of 60 –80 years age group by the authors. The old people are physically, psychologically and financially weak due to poor health condition, less attention and respect from the family members/ care takers and they also do not like vast social change in the name of modernization. They complain about poor attendance of care takers, unavailability of suitable entertainment programs during leisure time, ever shortage of money etc. They hardly find better social environment of their time, neither at home nor in Briddhashram. However, still many of them are happy to live in Briddhashram rather than with their youngsters in exploited environment at home.

WRAP UP SESSION

After completion of all the three presentations Mr. Kaphle, the Chairman of the Technical Session wrap up the session by pointing out the importance of the Theme of the Workshop and related research papers presented in the Technical Session and their main findings and conclusions. At that time he mentioned that all the presentations and follow up discussions were quite interesting and fruitful. It was an additional opportunity for us to learn more regarding Geo-science, disaster and the vulnerable people. Government must give high priority in pre-disaster preparedness as well as post disaster rescue and relief operation and rehabilitation of disaster victims at the earliest. It will be better to share experience with the senior citizens while preparing a disaster management plan by multidisciplinary expert team.

ABSTRACT OF THE IDDR-DAY 2014 PRESENTATIONS

Older people and management of geodisasters in Nepal

Ranjan Kumar Dahal

Department of Geology, Tribhuvan University, Tri-Chandra Campus, Ghantaghar, Kathmandu, Nepal

Geologically young and tectonically active mountainous terrains of the Nepal Himalaya are characterized by dynamic physical processes, and therefore, management of geodisaster is a big challenge. A better understanding of the geological nature of the terrain and the interaction of various triggering factors of geodisaster will greatly help in the development of safer infrastructures, management of geodisaster, and encourage communities for geodisaster resilient. Over the years, Nepal has gained a significant experience in geodisaster studies, especially in design and survey of geodisaster mitigation programs, in the fields of hazard and risk assessment, in low cost rural road engineering; in community based river training work and in slope maintenance incorporating indigenous techniques. This presentation provides an overview of geodisaster in Nepal and its mitigation efforts. In this paper, all geodisaster issues of Nepal are evaluated from the perspective of their occurrences and management issues. Geodisaster management efforts of both governmental and non-governmental sectors are also evaluated. Communities' perception for geodisaster management efforts are also discussed in this presentation. Whenever a geodisaster occurs, it does not only affect a specific group of people but all. In most cases, children and elderly people get more affected because they are mostly helpless and need more care. Older people are often excluded or marginalized when geodisaster management plans are being drawn up at community level. For this reason, it is very important to make sure that geodisaster management in Nepal involves the old persons to get their views and recommendations too. It will certainly help to build up geodisaster resilient communities in Nepal.

SEVENTH NEPAL GEOLOGICAL CONGRESS (NGC-VII)

"Geosciences in Sustainable Development: Challenges and Opportunities"
April 7-9, 2015
Kathmandu, Nepal

Organized by

Nepal Geological Society

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Seventh Nepal Geological Congress

April 07 – 09, 2015

Kathmandu, Nepal

Day 1: April 07

Inaugural Ceremony

NGC-VII Inauguration by the chief guest, Prof. Dr. Jibaraj Pokharel, Vice-Chancellor, Nepal Academy of Science and Technology (NAST), Nepal

S. N.	Time	Activity
1	17:00-17:35	
4	17:35 -17:40	Welcome speech by Dr. Dinesh Pathak, President, Nepal Geological Society
5	17:40 -17:45	Inauguration of the Congress by Prof. Dr. Jibaraj Pokharel, Vice-Chancellor, Nepal Academy of Science and Technology (NAST)
6	17:45 -17:50	Dr. Dinesh Pathak, President, Nepal Geological Society offers gift to the chief guest, Prof. Dr. Jibaraj Pokharel, VC, NAST
7	17:50 -17:55	Briefing about Seventh Nepal Geological Congress by Prof. Dr. Vishnu Dangol, Convener, NGC-VII
8	17:55 -18:05	Handover of certificates to the newly nominated Four Honorary Members of Nepal Geological Society by the chef guest, Prof. Dr. Jibaraj Pokharel
9	18:05 -18:15	Expression of Best Wishes – Prof. Dr. Georges Mascle, Newly nominated Honorary Member of NGS – Prof. Dr. Bishal Nath Upreti, Newly nominated Honorary Member of NGS
10	18:15 -18:25	Address by the chief guest, Prof. Dr. Jibaraj Pokharel, Vice-Chancellor, Nepal Academy of Science and Technology (NAST)
11	18:25 -18:30	Vote of thanks by Mr. Dinesh Napit, General Secretary, Nepal Geological Society and closing of the ceremony
12	18:30 -21:00	Welcome Diner

Welcome speech by Dr. Dinesh Pathak, President of NGS

Hon'ble Chief Guest, Prof. Jibaraj Pokharel, Vice Chancellor, Nepal Academy of Science and Technology (NAST)

Honorary Fellow Members, Former Presidents and Members of Nepal Geological Society

Former Minister and Parliamentary Member, Mr. Gangalal Tuladhar

Respected dignitaries from the Government of Nepal

Distinguished guests, participants and delegates of 7th NGC

Media personnel, ladies and gentlemen,

I on behalf of the 16th Executive Committee of the Nepal Geological Society, the organizing committee, members of the Society and on my own behalf, feel greatly privileged and humbly honored to welcome you all to this inaugural ceremony of the 7th Nepal Geological Congress. I welcome all the distinguished geo-scientists participating in this event from 23 countries, representing five continents.

Nepal Geological Society, established in 1980, is the umbrella organizations of all geoscientists of Nepal as well as of those working on Himalayan Geology. At present, over 700 members of the Society include geoscientists (Geologist, hydro-geologist, engineering geologist, geotechnical engineer, environmental engineer, mining engineer) not only from Nepal but also from various countries of Asia, Europe, Americas and Australia as well.

As part of the regional and international scientific cooperation, the Society regularly organizes national and international workshops, seminars, congresses etc. Within the last 35 years, it has gradually emerged as an important regional scientific organization and we have already successfully organized almost a dozen such large international scale scientific events, notably are:

Himalaya Karakoram Tibet (HKT) workshop: 9th in 1999 and 27th in 2012

Fifth Asian Regional Conference on Engineering Geology for Major Infrastructure Development and Natural Hazards Mitigation in 2005

International Symposiyum on Engineering Geology, Hydrogeology and Natural Disaster with emphasis on Asia in 1999

International Seminar on Hydrology with Special Colloquium on Environmental Problems and Water Resources of the Himalaya in 1993

In addition, as a series of scientific activities, the Society has been regularly organizing Nepal Geological Congress since 1995 in order to bring together geo-scientists of the south and southeast Asian regions and other parts of the world to share expertise, experiences and knowledge. So far, it has already organized six Geological Congresses in 1995, 1997, 2001, 2004, 2007 and 2010. Our events are getting stronger and strengthening in terms of number of participants and number of countries and the professionals that are represented through quite a large number of papers to be presented.

This Seventh Nepal Geological Congress is being organized for 3 days, from April 7 to 9, 2015. The main theme of the Congress is "Geosciences in Sustainable Development: Challenges and Opportunities". We do expect that this Congress would be a means for sharing our vision towards the need of development, promotion and application of the Geo-scientific knowledge for the sustainable development of the nation and explore challenges within it.

The Society received UN-Sasakawa Disaster Prevention Award by UN Humanitarian and Emergency Relief Co-ordination Office of IDNDR Secretariat in Geneva for its efforts in disseminating the scientific knowledge and spreading the awareness of prevention of the natural disaster in 1998. It also received "Science and Technology Promotion Award 2069-2070" in 2013 by Nepal Academy of Science and Technology (NAST) for its significant contribution to promote Geoscience Profession in the country.

NGS has been able to effectively establish an international network. It is the Associated Society of Geological Society of America (GSA) and National Group of International Association of Engineering Geology (IAEG). It is well recognized and supported in various activities by International Geological Congress (IGC) and The World Academy of Sciences (TWAS).

These are some of the milestones in achieving the goals of NGS towards professional development and contribution in the task of national development.

The presence of Rt. Honorable President of Nepal in our previous programs and VC-NAST, today at this opening program, in spite of his busy schedule and many hurdles, is a reflection that Nepal Geological Society is well recognized at the national level.

We have received outstanding support from the government an dacademic as well as international organization. An event like this cannot happen overnight. Motivation and dedication of many colleagues, especially Convener of the Congress Prof. V. Dangol, the Members of the Advisory board, Organizing Committee, Editorial Board of the Journal of Nepal Geological Society and volunteers are noteworthy for driving this event towards a success.

Once again, I extend warm welcome to you all in the inauguration ceremony of the Seventh Nepal Geological Congress.

Thank you !

April 7, 2015

Speech of Professor Dr. Vishnu Dangol, Convenor, 7th Nepal Geological Congress (NGC - VII)

Nepal Geological Society (NGS) organized the **Seventh Nepal Geological Congress** (NGC - VII) - an international geo-scientific event in Kathmandu, Nepal during April 7-9, 2015. The main theme of the Congress was "**Geosciences in Sustainable Development: Challenges and Opportunities"**. The Congress aimed to exchange expertise, experiences and knowledge for building effective cooperation among the geoscientists from all over the world. Prof. Jibaraj Pokharel, Vice Chancellor, Nepal Academy of Science and technology (NAST); Mr.Gangalal Tuladhar, Former Minister and Parliament member; Er Ganesh Shah, Former Minister; Mr. Rameshwor Khanal, Chairperson, Rastrapati Chure-Madhesh Terai Development Board, the NGS member and well- wishers join the inaugural session. A total of 109 oral and 21 poster presentations were made during the Congress. One-day post-Congress excursion was organized along the Arniko Highway on April 10th.

To organize the Congress, NGS had formed a 59-member organizing committee and 19-member advisory committee, which included a number of high ranking officials of Nepal and eminent scientists from Nepal and abroad. The sub-themes of the Congress were:

(a) Regional Geology, Stratigraphy and Tectonics
(b) Mineral Resources and Mining
(c) Oil and Natural Gas
(d) Seismology and Seismo-tectonics
(e) Hydropower and other Infrastructure Development
(f) Hydrogeology and Engineering Geology
(g) Quaternary Geology and Urban Geology
(h) Exploration Geophysics
(i) Disaster Management
(j) Climate Change and Environmental Assessment
(k) Geo-heritage and Geo-park Conservation and Development
(l) Geoscience Education
(m) Remote Sensing and GIS

An overwhelming response was received for scientific and research paper presentation in the Congress. 166 abstracts had been received from 23 countries (Armenia, Australia, Bangladesh, Bhutan, China, France, Germany, India, Indonesia, Iran, Italy, Japan, Korea, Morocco, Nepal, Philippines, Pakistan, Poland, Russia, Singapore, Thailand, United Kingdom and USA. This was truly appreciable for the kind gesture shown towards us by the respondents. However, some authors informed their absence in the Congress due to unavoidable personal matters. Hence, only 151 of received papers are published in the Journal of Nepal Geological Society, Special Issue, Volume 48.

As a great deal of geo-scientific research has been carried out by different researchers in the world, the Seventh Nepal Geological Congress became an excellent platform for the scientists of the world to come together and discuss their findings. The NGC-VII facilitated to scientists of 23 countries from all the continents of the globe for closer interaction between them belonging to different interrelated geo-scientific disciplines.

Though a general strike in Nepal was called by opposition parties during the period of the NGC-VII, the Congress was successfully organized in Hotel Yak and Yeti, Kathmandu. The Congress was participated by nearly 200 people, among which a quarter was from abroad. The organizers were very thankful to Prof. Dr. Jibraj Pokharel, Vice Chancellor of Nepal Academy of Science and Technology (NAST), who took a great trouble to reach the venue during the troubled day (7th April) and to encourage us and also for spending his valuable time to inaugurate this scientific Congress. Similarly, we got the encouragement from all the distinguished guests and participants who had reached to the venue walking a long distance from different parts of the Kathmandu Valley.

There were 17 oral Sessions including 3 keynote and 1 special paper sessions, and 2 Poster Sessions. Altogether 109 oral and 21 poster presentations on 12 themes were done. The presenters included not only seasoned and highly experienced scholars, but also by fresh students and Ph.D. scholars. The floor also very actively participated in the discussion with genuine questions, decent comments and superb suggestions for future researches.

Continuous and large contributions to researches and publications on Geology of Himalaya by Prof. Dr. Georges Mascle (France) and Prof. Dr. Bishal Nath Upreti (Nepal) were greatly recognized by the Nepal Geological Society. Prof. Mascle and Prof. Upreti were conferred honorary fellows of the Society. The certificates and tokens of appreciations were handed over to them by Prof. Dr. Jibraj Pokharel, Vice-Chancellor, Nepal Academy of Science and Technology (NAST) during the inaugural session of the Congress.

The event could not have been organized without the great help of national and international institutions who have helped us financially and logistically. Support from the NGS Executive Committee and suggestions from the members of the Organizing and Advisory committees during several meetings as well as through call and emails were really instrumental for organization of the Congress. The organizer is grateful to the following organizations for their generous financial and other necessary supports to organize this event.

- Department Analyse Surviellance Environnment (DASE), France

- Nanyang Technological University, Earth Observatory, Singapore
- International Centre for Integrated Mountain Development (ICIMOD), Nepal
- President Chure - Terai - Madhesh Conservation Development Board, Nepal
- Poyry Infra AG, Switzerland
- Hifab International Ltd., Sweden
- B. P. Koirala India-Nepal Foundation, Embassy of India, Nepal
- Nepal Academy of Science and Technology (NAST), Nepal
- Department of Mines and Geology, Nepal
- Department of Geology, Tri-Chandra Campus, Tribhuvan University, Nepal
- Central Department of Geology, Tribhuvan University, Nepal
- Department of Irrigation, Nepal
- Nepal Electricity Authority, Nepal
- Maruti Cements Pvt. Ltd., Nepal
- Sonapur Cements Pvt. Ltd., Nepal
- Nigale Cement Pvt. Ltd., Nepal
- Kanchan Quarries, NepalKepy Cement Pvt. Ltd., Nepal
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- Nissaku Co. (Nepal) Pvt. Ltd., Nepal
- Subham Khanij Udhyog Pvt. Ltd & Samrat Cements Pvt. Ltd., Dang, Nepal
- Geo Mining and Engineering Consultancy, Hetauda, Nepal
- Arghakhanchi Cement Udhyog Pvt. Ltd., Nepal

Thank you!

Speech by Mr. Dinesh Napit, General Secretary, NGS

Respected chairman of this inaugural session and president of Nepal Geological Society, Dr.Dinesh Pathak
Chief Guest, Prof. Dr. Jeev Raj Pokhrel, Vice chancellor, NAST
Prof.Dr. Vishanu Dangol, Converner, 7th Nepal Geological Congress
Prof.Bishal Nath Upreti, Honorary Memaber and Past President, Nepal Geological Society
Prof George Mascle, Honorary Memaber, Nepal Geological Society
Past presidents of NGS
Honarary members of NGS
Distinguised Guests
Members of Organizing Committee
Members of Executive committee
Scientists, academia, researchers and media personnel

On behalf of Nepal Geological Society, the organizing committee and myself, I am privileged to thank all the distinguished personalities and guests of the inaugural session and participants of the 7th Nepal Geological Congress "**Geosciences in Sustainable Development: Challenges and Opportunities**". We would like to express our sincere gratitude to our respected Chief Guest, Prof. Dr. Jibraj Pokharel, Vice-Chancellor, Nepal Academy of Science and Technology (NAST), for accepting our invitation, inaugurating the 7th Nepal Geological Congress and delivering comprehensive inaugural speech. We believe that Prof. Pokharel is well aware about the importance of geoseicens, and during his tenure, we hope that NAST will take initiative for further strengthening of geosciences through geoscientific research and its application in the sustainable development of Nepal.

Nepal Geological Society and all its members are very much happy to take this opportunity to honor both Prof. Bishal Nath Upreti and Prof. George Mascle as the honorary members of the Society in this august gathering.

We are indebted to Prof. Bishal Nath Upreti for his valuable presence and encouraging speech. Prof. Upreti has made great effort and contribution to strengthen geological education and research activities in Nepal and also contributed a lot to bring Nepal Geological Society at this prestigious level. Similarly, we are very much thankful to Prof. George Mascle for his presence. Despite his tight schedule and difficulties on the way, he managed to attend the ceremony. Prof. Mascle is always encouraging to all of us through his valuable scientific research contribution on the Himalayan Geology. We also express our heartfelt gratitude to all the guest and participants, who accepted our invitation and attended this congress to make it successful.

Nepal Geological Society would like to expresses its sincere thanks to the following organization for providing their generous financial support, without which the Congress would not have been successful: Department Analyse Surviellance Environnment (DASE), France; Nanyang Technological University, Earth Observatory, Singapore; International Centre for Integrated Mountain Development (ICIMOD), Nepal; President Chure-Terai Madhesh Conservation Development Board; Poyry Infra AG, Switzerlandand Hifab International Ltd., Sweden; B. P. Koirala India-Nepal Foundation, Embassy of India, Nepal; Nepal Academy of Science and Technology (NAST), Nepal; Maruti Cements Pvt. Ltd.; Shivam Cements Pvt. Ltd.; Shakti Mineral Pvt. Ltd.; Palpa Cements Pvt. Ltd.; Sarbottam Cements Pvt. Ltd; Sidhartha Minerals Pvt. Ltd.; Sonapur Cements Pvt. Ltd.; Jagadamba Cements Pvt. Ltd.; Cosmos Cements; Kepy Cement Pvt. Ltd.; Kanchan Quarries; Nigale Cements Pvt. Ltd.; Bhardeu Cements Pvt. Ltd.; CG Cements Pvt. Ltd.; Subham Khanij Udhyog Pvt. Ltd. & Samrat Cements Pvt. Ltd.; Geo Mining and Engineering Consulatancy, Hetauda, Nepal; Subhashree Agni Cement Udhyog Pvt. Ltd. and Annapurna Quarries Pvt.Ltd.

Department of Mines and Geology, Department of Irrigation, Tribhuvan Universiy, Nepal Electricity Authority, Department of Water Induced Disaster Preparedness have always been supporting the society by providing all kind of help at the time of its necessity. On behalf of the society, I would like to express our sincere appreciation and acknowledgements to all of these organizations.

Member of the organizing committee and the secretariat of the congress, who contributed their time and energy whenever required to make the congress a success are duly acknowledged for their endeavor.

NGS constituted a committee of three persons, Mr. Jagadiwhwor Nath Shresthta, past president of NGS; Dr. Suresh Das Shrestha, TU and Mr. Lila Nath Rimal, DMG to recommend the names of two honorary fellows. They worked hard in assessing the members, and finally came with the names of Prof. Bishal Nath Upreti and Prof. George. Mascal. We are grateful to the committee members.

The organization of the congress would not have been possible without the valuable contribution of papers and presentation by the distinguished experts in the technical sessions. We extend our sincere thanks to all the contributors.

Our thanks go to Hotel Yak and Yeti for providing this venue for the Congress. We would like to thank to the entire media person who convey our objectives to the general public. Finally, I thank you all for your gracious presence.

Thank you.

Dinesh Napit
General Secretary
Nepal Geological Society
16th Executive Committee (September 2013- September 2015)

Glimps of Photographs of the 7th Nepal Geological Congress

President of NGS, Chief Guest, Convenor, Honorary Members, guests and other representatives from different countries in the inaugural session.

Dr. Dinesh Pathak, President of NGS delivering welcome speech in the inagural session, and Mr. Dinesh Napit, General Secretary of NGS conducting the programme.

Prof. Dr. Vishnu Dangol, Convener-7th Nepal Geological Congress delevering speech in the inaugurational session.

Prof. Dr. Jibaraj Pokharel, Vice Chancellor, Nepal Academy of Science Technology and Chief Gust of the programme inaugurating the programme by lighting the lamp.

Participants of the 7th Nepal Geological Congress.

Glimps of Photographs of the Honorary fellowship Distrubution

Prof. Dr. Jibaraj Pokharel, Chief Guest of the inaugural session offering the Honorary Fellowship Award to Prof. Dr. Bishal Nath Upreti.

Prof. Dr. Jibaraj Pokharel, Chief Guest of the inaugural session offering the Honorary Fellowship Award to Prof. Dr. George Mascle.

Dr. Dinesh Pathak, President of NGS Providing Token of Love from NGS to Honorary Fellow Prof. Dr. Bishal Nath Upreti.

Prof. Dr. Vishnu Dangol, Convenor 7th Nepal Geological Congress offering Flower Buke to Honorary Fellow Prof. Dr. Bishal Nath Upreti.

ARTICLES

Geological source and sink of the atmospheric CO_2: Contributing to the global climate change?

Danda Pani Adhikari

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ABSTRACT

Climate change is taking place and it is caused by the anthropogenic CO_2 emissions that have been resulted from short-term cycling of carbon between biological, atmospheric, and oceanic reservoirs. The long-term budget of the CO_2 in the ocean-atmosphere system, on the other hand, is controlled by inputs from volcanism, metamorphic devolatilization, and chemical weathering of carbonate and silicate minerals, and roles of CO_2 on climate change from these geological sources is currently ignored for the current and future changes because geologic component of the carbon cycle operates slowly in comparison to the other parts of the global carbon cycle and because it is hard to detect and quantify them precisely. In geological system, metamorphic and volcanic process and carbonate formation in oceans are the long-term sources of atmospheric CO_2, while carbonate and silicate weathering are long-term sinks. The Himalayan metamorphic processes provide a source of CO_2 that is larger than the consumption of CO_2 by weathering of the Himalayan rocks. Growing number of studies in recent days suggest that collisional orogenic processes produce and consume CO_2 and likely to have positive feedbacks to climate warming. Global climate on the geological time scale is therefore controlled by the difference between the relatively large and variable orogenic-moderated degassing and weathering CO_2 flux. At present, CO_2 from the geological sources is not likely to have been contributing significantly to the climate changes the world has experienced, but it contributed greatly in the past, and may appear as potential contributor in future.

Key Words: Carbon source, carbon sink, metamorphic degassing, collisional orogenic process, CO_2 flux

INTRODUCTION

During the past century the global climate warmed by about 0.80°C and is attributed to anthropogenic CO_2 levels rising in the Earth's atmosphere. The global CO_2 concentration increased from ~277 (parts per million) ppm in 1750 to 402 ppm in 2015 (45% increase), and it is accompanied with changes in rainfall patterns, extreme weather events and sea levels. These changes are already having major impacts on the economic performance of developing countries and on the lives and livelihoods of millions of poor people around the world. Under business as usual scenario, another 1.40°C-5.80 °C temperature rise is projected in the next hundred years (IPCC 2007), whereas added global warming of more than 1 ºC above the level in 2000 can have various disruptive effects on global climate (Adhikari 2013). Figure 1 (a) and (b) shows trend of temperature and atmospheric CO_2 concentration change since the instrumental measurement started. Being an issue of global concern, climate change has therefore been in the forefront of scientific and public debates since the last few decades.

Amid the above understanding, recent study (e. g. NOAA 2015) further suggested an average temperature across global land and ocean surface temperatures combined for

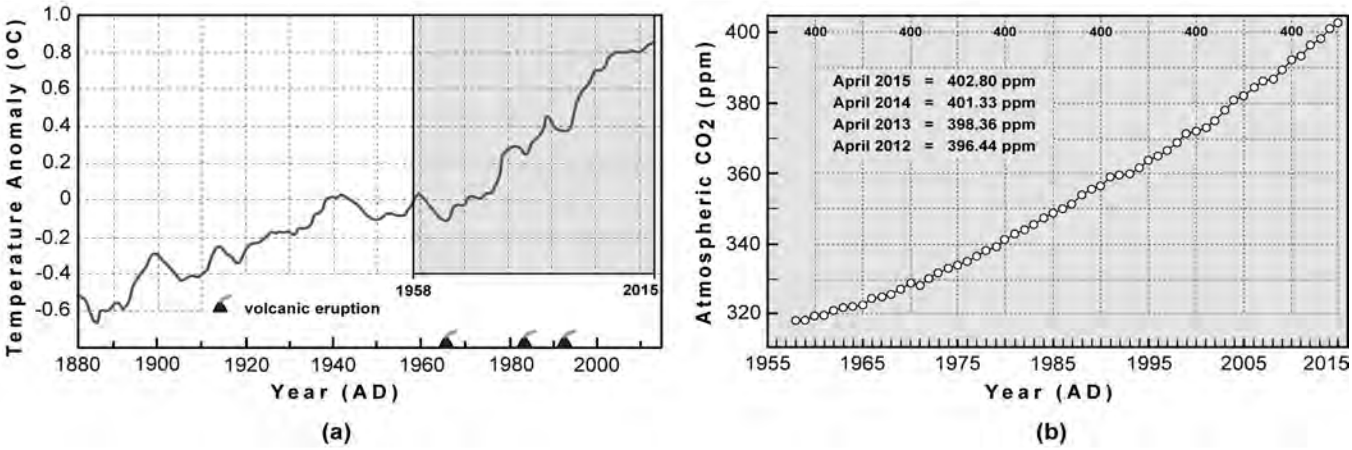


***Fig. 1:** (a) Global temperature anomaly (5-year running mean) for 1880-2015 relative to 1950-1980 mean (Data source: NASA GISS 2015; available at http://www.giss.nasa.gov/). (b) Globally averaged surface atmospheric CO_2 concentration from April 1958-April 2015 as recorded at Mauna Loa Observatory, Hawaii (Data source: Scripp Institute of Oceanography, 2015, https://scripps.ucsd.edu/). For comparison, the temperature anomaly pattern for the corresponding period of CO_2 measurement is shown in the shaded box in (a).*

March 2015 was 0.85°C higher than the 20th century average of 12.70°C. This marks the highest March temperature in the 136-year period of record, surpassing the previous record of 2010 by 0.05°C. Seven of the past eleven months (May, June, August, September, October, and December 2014, along with March 2015) have set new record high monthly temperatures. Most of Europe, Asia, South America, eastern Africa, and western North America were much warmer than average. The impacts of higher temperatures, more variable precipitation, more extreme weather events, and sea level rise are already impacting all sectors and will likely continue to intensify. Although aggressive mitigation of greenhouse gas emissions is crucial if dramatic long-term changes are to be averted, most of the changes projected for the coming decades can no longer be avoided (IPCC 2007). Climate scientists say we have years, not decades, to stabilize CO_2 and other greenhouse gases.

In climate change research, much attention has been focused on short time scale fluctuations in atmospheric CO_2 levels that result from cycling of carbon between biological, atmospheric, and oceanic reservoirs (e.g. IPCC 2007). However, cycling on longer time scales via geological processes is ignored in predictions of the future evolution of atmospheric CO_2 levels and its roles in future climate change. This paper gives an overview of the main geological processes that are source or sink of the atmospheric CO_2, and highlight its contribution to global climate change.

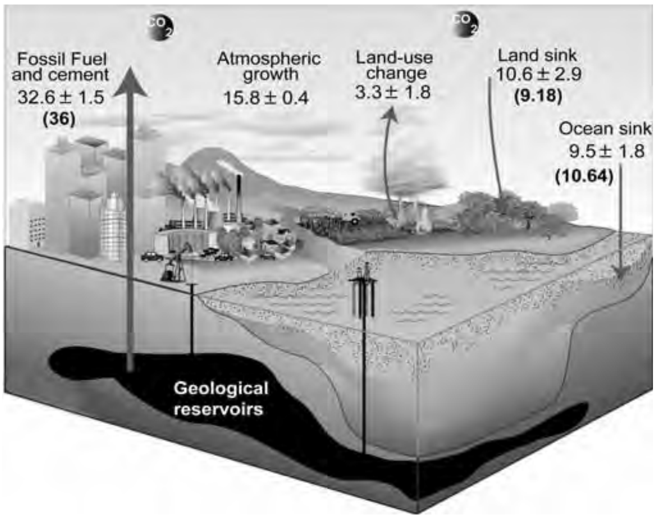


Fig. 2: Perturbation of the global carbon cycle caused by anthropogenic activities [averaged globally for the decade 2004–2013 (gigatonnes of CO_2 per year - $GtCO_2$/yr)]. Numbers in brackets represent data for 2013 (Data: http://www.globalcarbonproject.org/carbonbudget).

Global carbon budget

It has been known (e. g. NOAA 2015) that global CO_2 emissions due to fossil fuel burning and cement production in 2013 were 36 gigatonnes ($GtCO_2$), which is 61% higher than 1990 (the Kyoto Protocol reference year) and 2.3% higher

***Table 1:** Global ranks of the top CO_2 emitting countries in 2005 and 2013. China has been the largest (number one) CO_2 emitter in the world since 2006 leaving the USA behind*

S. N.	Country	Year 2005		Year 2013		
		CO_2 emission ($MtCO_2$)	Global rank	CO_2 emission ($MtCO_2$)	Global rank	Emission growth compared to 2005 (%)
1	USA	5822	1	5233	2	-10
2	China	5785	2	9977	1	+72.5
3	Russian Federation	1614	3	1812	4	+12.30
4	India	1410	4	2407	3	+70.70
5	Japan	1237	5	1246	5	+0.73
6	Germany	806	6	759	6	-5.80
7	Canada	563	7	503	10	-10.66
8	UK	542	8	462	14	-14.76
9	Italy	473	9	353	16	-25.37
10	Iran	469	10	611	8	+30.30
11	South Korea	463	11	616	7	+33.00
12	Mexico	435	12	466	13	+7.13
13	Saudi Arabia	397	13	519	9	+30.70
14	South Africa	396	14	448	15	+23.23
15	Brazil	347	18	482	12	+38.90
16	Indonesia	342	19	494	11	+44.44
17	**Nepal**	**3.2**	**126**	**4.3**	**127**	**+34.37**

$MtCO_2$: Metric tons of carbon dioxide (1 billion metric tons = 1 gigatons).
Data source: http://www.globalcarbonatlas.org/?q=en/emissions

than 2012. Figure 2 illustrates global CO_2 budget for 2004-2013. In 2013, the emissions were dominated by emissions from China (28%), the USA (14%), the EU (28 member states; 10%) and India (7%). Growth rates of these countries from 2012 to 2013 were 4.20% for China, 2.90% for the USA,

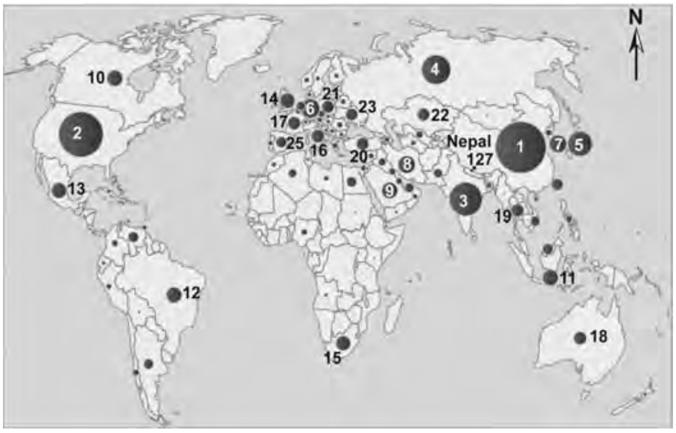


Fig. 3: (a) Global rank of the top CO_2 emitting countries in the world in 2013. The numbers indicate rank of the respective countries in the world (Data source: http://www.globalcarbonatlas.org/?=en/emissions).

-1.80% for the EU28, and 5.10% for India (http://www.globalcarbonprojectorg/carbonbudget/index.htm). The per-capita CO_2 emissions in 2013 were 1.40 tonnes of carbon person^{-1}yr^{-1} (5.10 tCO_2) for the globe, 4.50 (16.40 tCO_2) for the USA, 2.00 (7.2 tCO_2) for China, 1.90 (6.80 tCO_2) for the EU28, and 0.50 (1.90 tCO_2) for India. Table 1 and Figure 3 give the global rank of the top CO_2 emitting countries. The 2013 CO_2 emissions (fossil fuel and cement production only) breakdown is: coal (43%), oil (33%), gas (18%), cement (5.50%) and gas flaring (0.60%). Emissions from land use change accounts for 8% of total CO_2 emissions.

In 2013, the ocean and land carbon sinks respectively removed 27% and 23% of total CO_2 (fossil fuel and land use change), leaving 50% of emissions into the atmosphere (NOAA 2015). The ocean sink in 2013 was about 10.60 GtCO_2, slightly above the 2004-2013 average of 9.50 GtCO_2, and the land sink was 9.15 GtCO_2, slightly below the 2004-2013 average of 10.60 GtCO_2 (http://cdiac.gov/GCP/carbonbudget/2013). Total cumulative emissions from 1870 to 2013 were 390±20 GtC from fossil fuels and cement, and 145± 50 from land use change. The total of 535±55 GtC was partitioned among the atmosphere (225±5 GtC), ocean (150±20 GtC), and the land (155±60 GtC). [GtCO2 = 3.67 x GtC].

The current growth in global anthropogenic CO_2 emissions is tightly linked to the growth in Gross Domestic Product (GDP). The growth of the global GDP for 2013 was 3.30%, and the fossil fuel carbon intensity of the economy declined (improved) by -1.0% yr^{-1} (NOAA 2015). The 2014 projection of 2.50% growth was based on the world GDP projection of 3.30% made by the International Monetary Fund. The countries contributing most to the 2013 change in emissions were China (58% increase), USA (20% increase), India (17% increase), and EU28 (11% decrease) (http://cdiac.gov/GCP/carbonbudget/2013). In 1990, 62% of global emissions were emitted by the developed countries, 34% developing countries, and 4% in bunker fuels used for international shipping and aviation. In 2013, 36% of emissions were emitted in developed countries, while the developing countries emitted 58%.

CARBON CYCLE AND GEOLOGICAL CARBON

The carbon cycle

Media or materials that hold carbon are called carbon “sources”, while processes that absorb it are carbon “sinks” (Adhikari 2014). Forests, rocks, soils, oceans, the atmosphere, and fossil fuels are important stores of carbon, which is constantly moving between these different stores that act as either “sinks or sources.” The primary source of carbon/CO_2 is outgassing from the Earth's interior at midocean ridges, hotspot volcanoes, and subduction-related volcanic arcs (Berner 2004). Much of the CO_2 released at subduction zones is derived from the metamorphism of carbonate rocks subducting with the ocean crust. Much of the overall outgassing CO_2, especially as midocean ridges and hotpot volcanoes, was stored in the mantle when the Earth formed (Marty and Tolstikhin 1998). Some of the outgassed carbon remains as CO_2 in the atmosphere, some is dissolved in the oceans, some carbon is held as biomass in living or dead and decaying organisms, and some is bound in carbonate rocks. Carbon is removed into long term storage by burial of sedimentary strata, especially coal and black shales that store organic carbon from undecayed biomass and carbonate rocks like limestone (Berner 2004).

The amount of carbon in the atmosphere at any one time depends on the balance that exists between the sinks and sources. This system of sinks and sources operates all over the planet and is known as the carbon cycle. It is the transformation of CO_2 from sink to source that is resulting in increased global temperatures and global climate change (Adhikari 2013). The atmosphere is the largest sink a nd the amount of carbon in the atmosphere determines how high the future temperature goes up and affects our future environment.

Geological carbon Sources

Carbon in the Earth’s crust occurs as reduced or elemental carbon in graphite, methane, and other hydrocarbon phases, as oxidised carbon in carbonates, dissolved ionic species such as bicarbonate, or CO_2 in a gas or liquid phase (Evans 2011). Processes that transfer carbon between forms and reservoirs include diagenesis, hydrocarbon maturation, metamorphic devolatilization, silicate melting, fluid immiscibility, fluid mixing, carbonation, and mineral precipitation.

The geological processes represent both source and sink of atmospheric CO_2 (Figure 4). Besides the anthropogenic CO_2, the long-term global CO_2 budget is controlled by inputs from volcanism, metamorphic devolatilization, and the oxidation of sedimentary organic carbon. A dynamic balance is maintained by outputs to the sedimentary reservoir, through the processes of chemical weathering of silicate minerals and subsequent precipitation of sedimentary carbonates, and the burial of organic carbon.

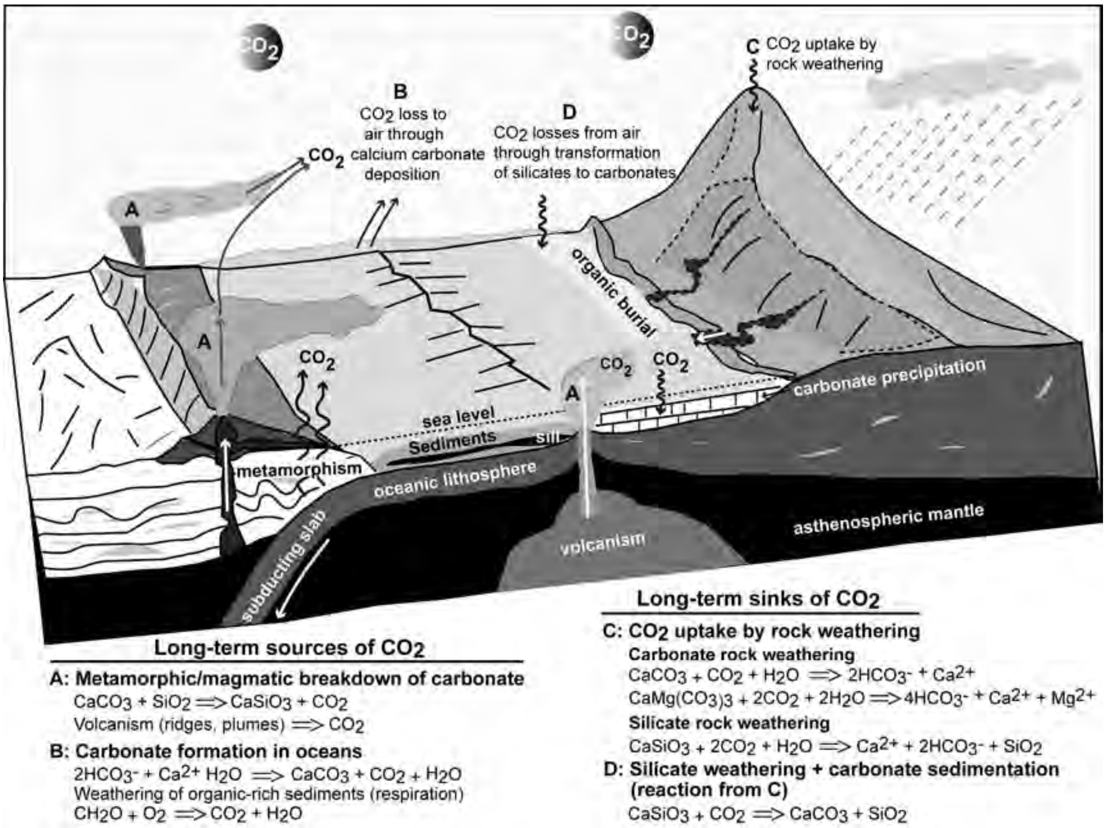
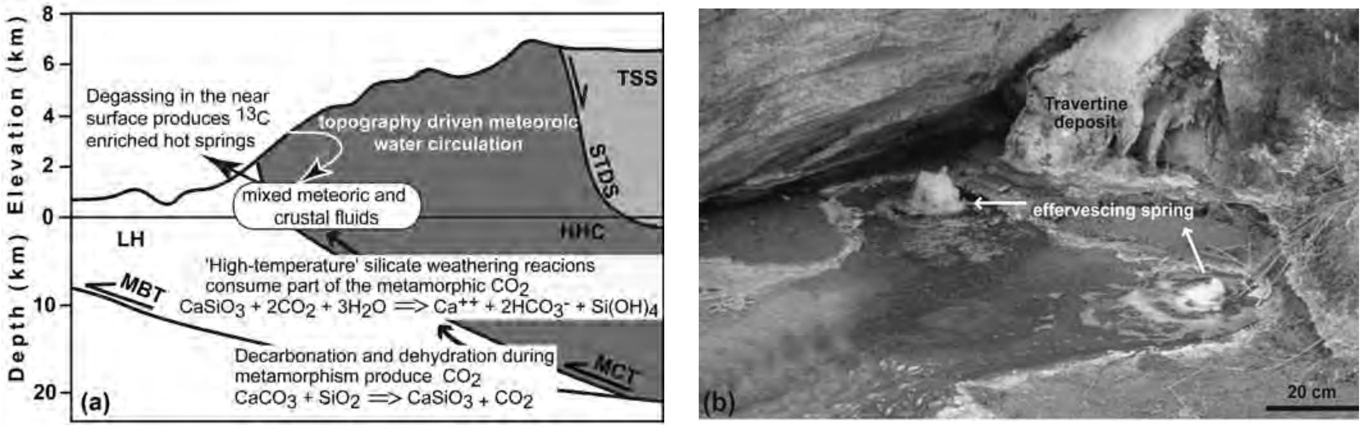


***Fig. 4:** Long-term sources and sinks of atmospheric CO_2 in geological system (modified after Gaillardet and Galy 2008).*



HHC: Higher Himalayan Crystalline; TSS: Tibetan Sedimentary Sequence; STDS: South Tibetan Detachment System; LH: Lesser Himalaya; MBT: Main Boundary Thrust; MCT: Main Central Thrust

***Fig. 5:** (a) Schematic representation of subsurface fluid (CO_2, H_2O) flow process to the surface in the Himalaya. Decarbonation and dehydration metamorphic reactions produce CO_2-H_2O fluids at 10-20 km depth. CO_2-rich fluid migrates up where they are entrained in local meteoric hydrothermal circulations driven by steep geothermal and topographic gradients (modified after Evans et al. 2008); (b) Effervescing CO_2-rich spring water in upper Marshyangdi River section, with travertine ($CaCO_3$) precipitates on rock surface (after Evans et al. 2008).*

Metamorphism

Contact metamorphism of sediments lead rapid gas generation from organic material and subsequent release of greenhouse gases to the atmosphere. Active collisional orogens, like the Himalaya, may have strong impact on the global carbon cycle through metamorphism. The Himalayan orogen is a type example of geologically active region produced by continent-continent collision and the metamorphism of carbonatepelite sediments associated with the ongoing India-Asia collision provides a quantitatively important source of CO_2 to the surface environment (Gaillardet and Galy 2008)). Metamorphic degassing in the Himalaya would supply a

significant fraction of the global solid-Earth derived CO_2 to the atmosphere and play a fundamental role even in today's Earth carbon cycle (e. g. Costa et al. 2015; Rolfo et al. 2015). Figures 4 and 5a, b illustrate some explanations on how CO_2 is generating deep inside and reach to the surface. Skelton (2011) estimates that metamorphic carbon fluxes through metasedimentary rocks that experienced greenschist facies regional metamorphism are 0.5–7 moles C m^{-2} yr^{-1}. This value is similar to values estimated for Himalayan carbon fluxes from hot springs (e.g. Becker et al. 2008).

Evans et al. (2008) estimated that the metamorphic degassing flux of CO_2 in the 32,000 km^2 Narayani River basin of the Nepal Himalaya exceeds the consumption of CO_2 by chemical weathering for the basin by a factor of four. If the geothermal degassing and dissolved inorganic carbon (DIC) flux from the Narayani basin is extrapolated as a first approximation of the CO_2 flux to the surface from Himalayan metamorphism, it becomes 7 to 60% of recent estimates of the global flux from volcanic arcs (Evans et al. 2008). Their study implies that the net impact of Himalayan orogenesis on the carbonate-silicate geochemical cycle is not large-scale drawdown of CO_2 because the weathering sink is substantially offset or even exceeded by the metamorphic source. The Himalayan metamorphic processes provide a source of CO_2 that is larger than the consumption of CO_2 by weathering of Himalayan rocks. Hot springs along Himalayan front carry large fluxes of CO_2 derived from metamorphic reactions.

Among the metamorphic reactions that produce CO_2, a few, not mentioned in Figure 4, are listed below:

3dolomite + $4SiO_2$+ H_2O ↔ talc + $3CaCO_3$ + $3CO_2$

dolomite + quartz + H_2O ↔ tremolite + calcite + C_O2

10calcite + 3chlorite + 21quartz ↔ 3actinolite + 2epidote + $10CO_2$ + $8H_2O$

$4Mg_3Si_4O_{10}(OH)_2$ + $5CaMg(CO3)_2$ ↔ $5CaMgSi_2O_6$ + $6Mg_2SiO_4$ + $10CO_2$ +$4H_2O$

Volcano

Volcanoes produce solid, liquid, and gas materials (Fig. 6), and all the gases of the Earth's atmosphere and all the water of the Earth's ocean are believed to have been released by volcanic activities (Adhikari 2014). CO_2 from erupting magma and from degassing of unerupted magma beneath volcanoes is the mail component potential for climate change of different magnitude. Geological evidences suggest Cretaceous Period (144-65 Ma), period with unusually high rate of volcanic activity was among the warmest in its history. The Period ended with the extinction of dinosaur, and is, generally, attributed to large magnitude abrupt climate warming due to enhanced green house gases (GHGs) effects of CO_2 emitted from the volcanoes. At present, the Earth is known to have about 1,500 active volcanoes and 50-70 of them normally erupt. The eruption of Mount Pinatubo in 1991, the second largest terrestrial eruption of the 20th century released about 0.05 Gt of CO_2 and the CO_2 from Mt. St. Helens during its 1980 eruption was about 0.01 Gt (Gerlach 2011). The present-day global CO_2 emissions rate for all degassing subaerial and

Fig. 6: Volatile materials emanating from Kilauea Volcano, Hawaii. (Photo source: http://www.kilaueaadventure.com/mount-kilauea-picture-gallery.php).

submarine volcanoes range from about 0.15 to 0.26 gigatons per year (Gerlach 2011). The 36 gigaton anthropogenic CO_2 emission for 2013 is about 240 times larger than minimum annual global volcanic CO_2 emission estimates. The contribution of current volcanic CO_2 to the ongoing climate warming is, therefore, negligible, but future volcanic eruptions can have additional role to determine how high the CO_2 in the atmosphere and hence future temperature (Adhikari 2014).

Geological carbon Sinks

Rock weathering

Carbon dioxide and the other atmospheric gases dissolve in surface waters. Carbon dioxide reacts with water in solution to form the weak acid, carbonic acid. Carbonic acid disassociates into hydrogen ions and bicarbonate ions. The hydrogen ions and water react with most common minerals (silicates and carbonates) altering the minerals. The products of weathering are predominantly clays (a group of silicate minerals) and soluble ions such as calcium, iron, sodium, and potassium (Houghton and Woodwell 1989). Bicarbonate ions also remain in solution; a remnant of the carbonic acid that was used to weather the rocks. Chemical weathering both shapes surface environments through formation of the soil mantle and affects global geochemical cycles such as the carbon cycle (Berner 1997).

Some basic reactions for carbonate and silicate rocks weathering are given in Figure 4, and they clearly shows that the carbonate rock weathering contributes to the atmospheric CO_2 sink. In the reactions, CO_2 may come from the atmosphere directly in bare carbonate rock areas, or from soil in overlying and/or buried carbonate rock regions (Harrison et al. 1993). In both cases, atmospheric carbon is captured in rivers and transferred to the ocean. It can be easily visulized from the above reactions that for limestone weathering, the removal of 1 mol $CaCO_3$ needs 1 mol of CO_2 from atmosphere; and for dolomite weathering, the removal of 1 mol $CaMg(CO_3)_2$ needs 2 mol of CO_2 from atmosphere. The net amount of CO_2 removed from the atmosphere in a given catchment area is equivalent to the total amount of limestone dissolved and transported outside the area via groundwater flow and/or rivers

(Berner 1997). Therefore, the net amount can be estimated by the limestone corrosion and the discharge of groundwater and/or rivers.

According to the data from the Guilin monitoring station in 1993-1996, the consumption of atmospheric CO_2 during carbonate rock weathering increased from 6.129× 10^9 $gCyr^{-1}$ in 1993 to 11.582× 10^9 $gCyr^{-1}$ in 1995 due to the increase of soil CO_2, which was related to reforestation and/or global increase in atmospheric CO_2 (Harrison et al. 1993). This means that the contribution of carbonate rock weathering to the atmospheric CO_2 sink increases with the lifting of the atmospheric CO_2 content. So, the carbonate rock functions as an adjustor to the atmospheric CO_2. Therefore, as an important and potential sink for the atmospheric CO_2, the carbonate rock weathering should be considered in the global carbon cycle model. Similar to carbonate rock weathering, Ca-silicate rock weathering provides feedback interaction with atmospheric CO_2 drawdown by means of carbonate precipitation ($CaSiO_3 + CO_2 \rightarrow CaCO3 + SiO_2$). The contribution of silicate weathering to the atmospheric CO_2 sink may be only 6%, while the other 94% is by carbonate weathering (Elderfield 2010).

Carbonate rocks occupy an area of about 22x10^6 km^2 in the world (Yuan, 1997). As the world's biggest carbon reservoir, carbonate rocks contain about 6.1x10^{16} tons of carbon, which is 1694 times and 1.1x10^5 times larger than those of oceans and world vegetation, respectively (Houghton and Woodwell 1989). The total amount of atmospheric CO_2 consumed in carbonate rock weathering would be about 4.114× 10^{14} g yr^{-1} for the whole world.

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अब्यवस्थित शहरी नदी करिडोर क्षेत्र तथा प्राकृतिक प्रकृयाः काठमाडौंका नदी क्षेत्रमा जोखिम न्यूनिकरणका चुनौतीहरू

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सारांश

शहरी नदी करिडोर र किनार क्षेत्र अति अव्यवस्थित स्थितिमा छन् । अव्यवस्थित बसोबास र नदी नालाका अतिक्रमणबाट नदीको वातावरण प्रायः क्षय भैसकेका छन् । त्यस्ता क्षेत्र भूकम्पीय, भूस्खलन तथा भिल्के बाढीबाट बढी प्रभावित हुन्छन् । नदी करिडोर क्षेत्रमा अन्यत्र भन्दा कमसल बलगुण तथा खुकुला बालुवा माटो हुने भएकाले त्यस क्षेत्रमा भूकम्पीय तरंग बढी अधिकताका साथ धिमा गतीमा तरंगीत भई संरचनाहरू बढी क्षती हुन्छन् । त्यस्तै खुकुला बालुवा माटोमा भूस्खलन तथा भूक्षय पनि निरन्तर हुने गर्दछ। तसर्थ नदी करिडोर क्षेत्र सकभर ठूलाठूला आवासगृह, घर टहरो तथा ठूला संरचना विहीन बनाउनु उचित हुन्छ। साथै नदी करिडोर क्षेत्रलाई खुला क्षेत्र कायम गरी नदी वातावरणलाई पुनर्स्थापन गरी संरक्षण गर्नुपर्ने देखिन्छ। यस कार्यका लागि सम्बन्धित निकाय र सरोकारवालाले यथाशीघ्र कदम अगाडी बढाउनु आवश्यक छ।

कत्तिको ब्यवस्थित छन् नदी किनार क्षेत्र?

वागमती नदी काठमाडौं उपत्यकाको मुल नदी हो (चित्र १) । काठमाडौं उपत्यकामा यसको जलाशय क्षेत्र ६७८ वर्ग किलोमिटर ओगटेको कटौरा आकारको छ। उपत्यकामा वागमती नदीको लम्बाई भण्डै ५१ किलोमिटर छ र यो नदी सातौं अर्डरमा पर्दछ। उपत्यकाको उत्तरपुर्वी क्षेत्रबाट शुरु भई दक्षिणपश्चिम भेगबाट वागमती नदी निश्कासन हुन्छ । त्यसक्रममा उपत्यकाको वरिपरी जलाशयबाट बगेका वागमतीका सहायक नदीनालाहरू जस्तैः विष्णुमती, धोबी, टुकुचा, मनहरा, हनुमन्ते, गोदावरी, कोड्कु, नख्खु, बल्खु, छैमले आदि पर्दछन् (Bajracharya and Tamrakar 2008; Tamrakar and Bajracharya 2009; Shrestha et al. 2011; Tamrakar et al. 2013)। प्रत्येक खोलाका उपल्लो धार क्षेत्रमा केही थोरै, अन्यथा तल्लो धार क्षेत्रमा अत्याधिक संरचना, घर टहरो इत्यादि निर्माण भएका छन् (Tamrakar 2004; Tamrakar 2014) । ती संरचना र बसोबास अतिनै अव्यवस्थित हुनाको अलावा नदीको बिभिन्न हिस्सा अतिक्रमीत भएका छन्। नदीलाई अतिक्रमण गरी धार परिवर्तन र बहावमा दखल हुने गरी पर्खाल र बाटो निर्माण भएको देखिन्छ (चित्र २) नदी किनार क्षेत्रमा देखिने दखलहरू निम्नबमोजिम छन् ः

(१) नदीमा बालुवा, माटो र ढुगाको उत्खनन्

(२) नदी किनारका वनस्पति पेटिको क्षयी तथा बिनाश

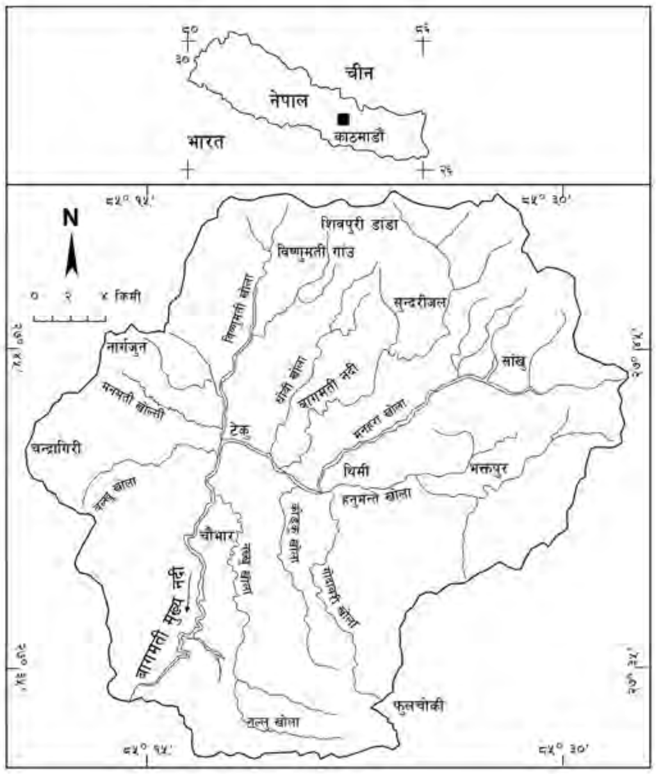
(३) कृषि, उद्योग, टहरो, बहुतल्ले भवन, बाटो, पुल, इत्यादिका लागी नदी किनार क्षेत्र जथाभावी अतिक्रमण

(४) फोहरमैला थुर्पाने, पुर्ने र फाल्ने कार्य तथा ढल नदीमा तेर्सिएको

(५) टुकुचा, सामाखुशी, बल्खु इत्यादी ससानो खोला र खोल्सीमाथी कंक्रीट स्लयाबले छोपी नदीलाई ढलको रूपमा परिवर्तन गरिएको

(६) नदीको उपल्लो धारमा पर्ने जलाशय क्षेत्रहरूबाट पानीको खिचाई अत्यधिक, जस्तै : शिवपुरी क्षेत्र, सुन्दरीजल, रानीबन, शेषनारायण, बल्खुखोला, कोड्कुखोलाको बाडीखेल, गोदावरी नदी आदि ।

माथी उल्लेख गरिएका दखलहरूमा स्थानिय निकाय र सरकारको सहभागिता समेत भएकाले यस्ता दखलहरू अनियन्त्रित रूपमा बृद्धी भएकाले काठमाडौ उपत्यकाको नदी तथा खोला दिनानु दिन भनभन अव्यवस्थित बन्दै गएका छन् ।



चित्र १: काठमाडौं उपत्यकाको बागमती नदी तथा तिनका खोलानाला ।

नदीका प्राकृतिक प्रकृया तथा जोखिमहरू

नदी उच्चभेगबाट निम्न थोरै समतर भेग सम्म बहनु निरन्तर प्रकृया हो । नदी किनार क्षेत्रमा विभिन्न प्रकृयाले असर तुल्याई रहेका हुन्छन् । निम्नलिखित प्रकृया

चित्र २: नदी करिडोर क्षेत्र (कोड्कु नदी)मा अव्यवस्थित तवरले निर्माण गरिएका संरचनाहरू। (क) नदीको वहाव क्षेत्रलाई खुम्च्याई बनाईएको पर्खाल, (ख) नदीको वहाव क्षेत्रलाई खुम्च्याई बनाईएको पर्खाल, बाटो र पुल, (ग) नदीको वहाव क्षेत्रलाई खुम्च्याई बनाईएको पर्खाल तथा कारखाना र (घ) नदी अतीक्रमण गरी निर्माण गरिएका अव्यवस्थित विद्यालय तथा बहु तल्ले आवासगृहा

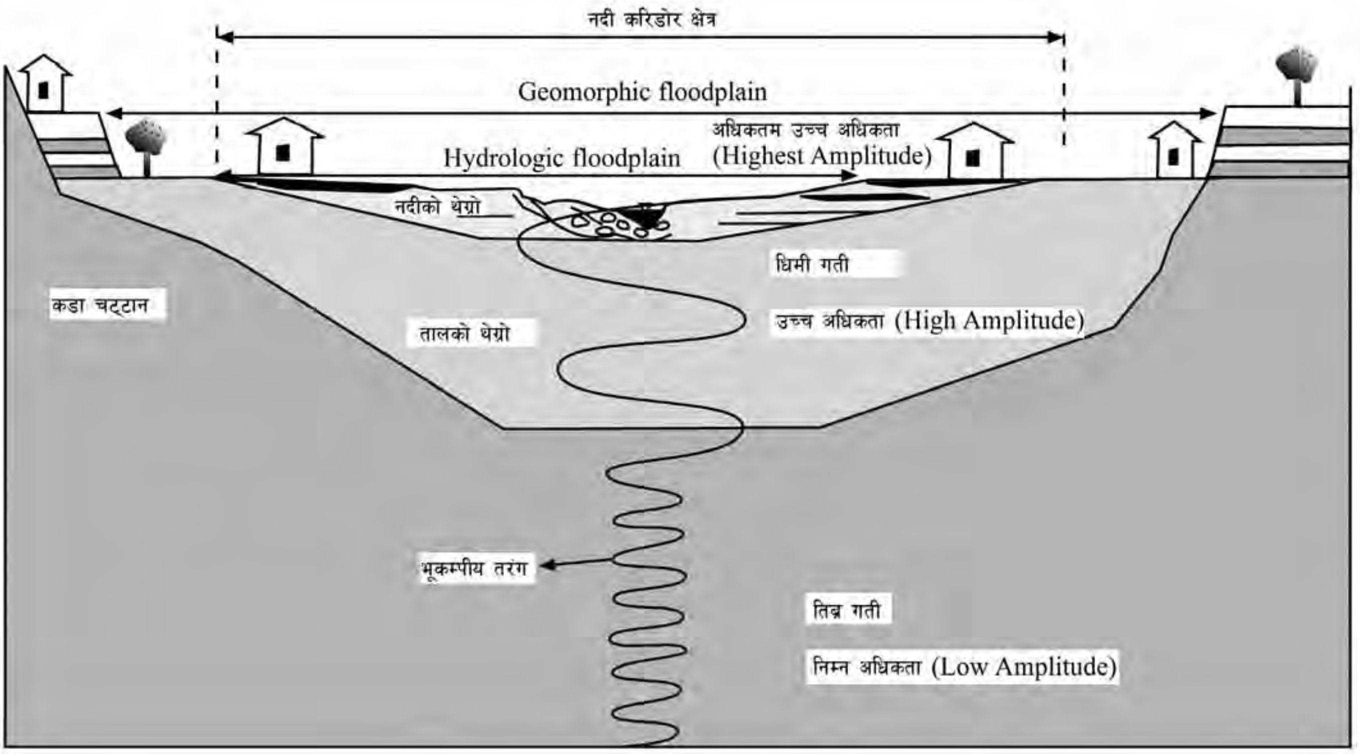
तथा तिनका जोखिमले नदी किनार क्षेत्र बढी प्रभावित भएका हुन्छन्।

(१) भूकम्पन तथा यससँग सम्बन्धित प्रकृयाहरू जस्तै :तरलीकरण तथा भूबिस्थापन, भूदरार तथा धांजाको उत्पति
(२) भूस्खलन (पहिरो, भूसराई तथा भूघस्साई)
(३) नदी कटान तथा भूक्षयीकरण
(४) नदी बहावमा ह्रास तथा झिल्के बाढी

(क) भू-कम्पन तथा योसित सम्बन्धित प्रकृयाहरू

धेरैजसो नदी तथा खोलाहरू उपत्यकाको उच्च भेग बाहेक तिनको मध्य र तल्लो धारहरू माटो बालुवाको थेग्रो (Sediment) माथी भई बगेका छन्। यस्ता थेग्रो उपत्यका वरिपरि क्षेत्रमा थोरै घना तर बिचको क्षेत्रतिर धेरै घना छन्। अधिकांश नदी र खोलाको मध्य धार र तल्लो धार बाक्लो वा घना खुकुलो, फुस्रो बालुवा र माटोको थेग्रो माथी बगेका छन्। त्यस क्षेत्रका जमीन कम्पन विस्तार (ground shaking amplification) बढी हुने गर्दछ। भूकम्प आउँदा कुनै क्षेत्रमा अरु क्षेत्रमा भन्दा धेरै गुणा असर पुग्न सक्दछ। यो भूकम्पको श्रोत नजिक वा टाढामा मात्र भर नपरी, भूगर्भको बनोटमा पनि भर पर्दछ।
काठमाडौं उपत्यकामा अवस्थित भूगर्भ मनन गर्नेहो भने त्यहां करीब ६०० मी बाक्लो तहमा माटो बालुवाको थेग्रो चट्टानमाथी पुरानो ताल हुंदाखेरी पुरिएर बनेको छ (Sakai 2001)। त्यस अलावा ताल सुकेपछि नदी नालाले थुपारेका थेग्रो पनि अवस्थित छन्। यस्ता खुकुलो थेग्रामा भूकम्पन (Peak Ground Acceleration, PGA) चट्टाने भूभागको प्रवाह गर्ने acceleration २.० g. हुन्छ भने रसाएको वलौटे माटो र धना बालुवाले ०.५०–०.६० g प्रवाह गर्न सक्दछ। माटोले ०.१०–०.१५ g भन्दा बढी acceleration प्रवाह गर्न सक्दैन। भूकम्पका तरंगहरू (Seismic waves) जमीनको भूवनोटमा निर्भर गर्दछ। कम्पनका तरंगहरूको गती चट्टाने भूभागबाट प्रवाह गर्दाको भन्दा थेग्रो पार गर्दाको गती भन्दा बढी हुने गर्दछ किनकी प्रवाह गती कम घनत्व भएको माटो बालुवा भन्दा बढी घनत्व भएको चट्टानमा बढी हुन्छ। माटो बालुवा मध्ये पनि त्यसको घनत्व पनि सतहबाट गहिराईको तहमा बढ्दै जान्छ। जब तरंगहरू कडा चट्टानबाट नरम चट्टान भई थेग्रोतिर आईपुग्दछ s-wave को गती पनि घट्दछ (चित्र ३) र यथावत तरंगका शक्ति सन्तुलनका लागि घनत्व घटी हँदा s-wave को गती बढ्नु पर्ने हुन्छ (Kramer 1996) त्यसपश्चात थेग्रोमा तरंगका अधिकता (amplitude) पनि बृद्धि हुन पुग्दछ (चित्र ३)।

तरंगका अधिकता र गतीका सम्बध नेगेटिभ छ भन्ने कुरा Borchordt



चित्र ३: नदी करिडोर क्षेत्रको भूवनोट तथा भूकम्पीय तरंगका अधिकता देखाईएको कार्टुन चित्र।

र Glassmoyer (1994) ले प्रस्ट्याएको थियो । तसर्थ चट्टान तथा बालुवामाटोको बर्गिकरण s-wave को गती (Vs) अनुसार कत्तिको कम्पन अधिकता (amplification) हुन्छ भन्ने कुराको आधारमा The National Earthquake Hazard Reduction Program (NEHRP) ले गरेका छन् (तालिका १) ।

तालिका १ः भूकम्पीय तरंगका गती र तरंगीत अधिकता का आधारमा चट्टान तथा बालुवामाटोको वर्गीकरण (NEHRP)

भूप्रकृती	Vs, मी/से	Remarks
A	>१५००	क्षयीकरण नभएको अग्नेय चट्टान
B	७५०-१५००	ज्वालामुखी चट्टान
C	३५०-७५०	केही Quaternary (<1.8 Ma) बालुवा, माटो, केही Tertiary (1.8-64 Ma) बलौटे चट्टान, माटीय चट्टान, चुना चट्टान
D	२००-३५०	Quaternary बालुवा, माटो र ग्राभेल (Significant Amplification)
E	<२००	पानी रसिएको बालुवा माटो र बनावटि पूरन् (Strongest Amplification)

Han et al. (1986) ले बलौटे चट्टानका लागी P-wave र S-wave velocity को छिद्रता (Porosity) र माटोको प्रतिशत (Clay%) सँग सम्बन्ध स्थापित गरेका छन् । जस्तै :

Vp (km/s) = 5.59-6.93 ϕ -2.18 C (जहाँ R^2=0.985)
Vs (km/s) = 3.52-4.91 ϕ -1.89 C (जहाँ R^2=0.959)

जहाँ, ϕ = Porosity (छिद्रता) % र c=clay content in % हुन् । ती समीकरणमा ϕ र c बढ्दा-घट्दा रहेछन् । Robert (1982) ले, ϕ र c शुन्य स्थापित गर्दा matrix को गती Vp को लागी ५.५९ km/s र Vs का लागी ३.५२ km/s पाए । जबकी Quartz aggregate को लागी त्यहि Vp र Vs कमश ६.०५ km/s र ४.०९ km/s हुन्छन् । (१-२% Vol. fraction) माटो (clay) ले पनि प्रभावकारी रूपमा matrix लाई नरम बनाईदिन्छ र गती त्यसमा घट्दछ । Han et. al. (1986) ले के पनि पाए भने गतीको ϕ र c सँगको सम्बन्ध रसाएको (Saturated) नमूनाको हकमा सुख्खा नमूना भन्दा राम्रो पाए । अर्को कुरा ϕ र c को असर Vp मा भन्दा Vs मा बढी देखियो । तसर्थ कुनै नमूना ϕ र c बढी हुंदा तिनमा Vp/Vs पनि बढि पाईयो । अर्को कुरा, Vp र Vs matrix नभएको बलौटे चट्टानमा matrix बढी भएको बलौटे चट्टानमा भन्दा धैरै पाईयो । अन्तःमा सफा बालुवामा बढी, matrix बढी भएको बलौटे चट्टानमा थोरै र त्यसभन्दा matrix बढी भएको तर रसाएको बलौटे चट्टानमा सबभन्दा थोरै दर्ता भए । अब यहाँ गती (velocity) जति कम भयो हल्लाउने अधिकता गती (amplification of shaking) बढी हुन्छ । जसले गर्दा भूकम्पन हुँदा चिरा पर्ने, तरलीकरण हुने, धाँजा फाट्ने, घरहरू र अरु संरचना भास्सीने र भत्किने हुन्छन् ।

(ख) भू-स्खलन

जब नदी किनारमा परिराखेको गुरुत्वाकर्षण बल माटो बालुवा थाम्न परिरखेको बल भन्दा बढी हुन्छ, तब भूस्खलन हुन पुग्दछ । शहरी नदीका किनारहरू प्रायःजसो तल्लो धार (downstream segment) भन्दा उपल्लो धार (upstream segment) बढी अग्लो हुने हुँदा यस्तो प्रकृया प्रायः उपल्लो

धारमा सिमित हुन्छ । तर नदीको तल्लो धारमा अवस्थित किनारमा पनि स-साना भूस्खलन हुने गर्दछ । यस्ता प्रकृया चट्टान भएका नदी किनारमा भन्दा माटो बालुवा भएका किनारमा बढी हुने गर्दछ किनकी एक त माटो बालुवाका गुण कमसल हुन्छ, अर्को नदीले भीरको फेद खियाईरहेको (scouring) हुन्छ । जस अनुरूप तल्लो फेद खिईएपछि माथिल्लो भिर थाम्न नसकि माथिल्लो भिरको स्खलन हुन पुग्दछ । माटो बालुवाको किनार क्षेत्रमा पनि माटो cohesive हुने र बालुवा cohesionless हुने भएकाले बिभिन्न प्रकारका भूस्खलन हुने कुरा नदी किनार क्षेत्रमा अवस्थीत ढुंगा, माटो बालुवा तथा चट्टानमा निर्भर गर्दछ । अर्को महत्वपूर्ण कुरा भिर (slope) को ज्यामिती पनि हुन । नदी किनारिय भूस्खलनका प्रकार (चित्र ४) निम्न बमोजिम छन्:

(१) **सतही साधा भू-स्खलन (Shallow Slide)**

कम गहिराईमा चिप्लने प्रकृया नदी किनार पट्टि हुने गर्दछ । प्राय: प्लास्टिक पातलो माटोको हिस्सा चिप्लेर स्खलितहुने प्रकृया धेरै ठूलो खालको नभएपनि निरन्तर चलिरहेमा नदी किनारिय भू-क्षयमा मद्त पुग्दछ ।

(२) **Rotational Slide (घुमाउरो भू-स्खलन)**

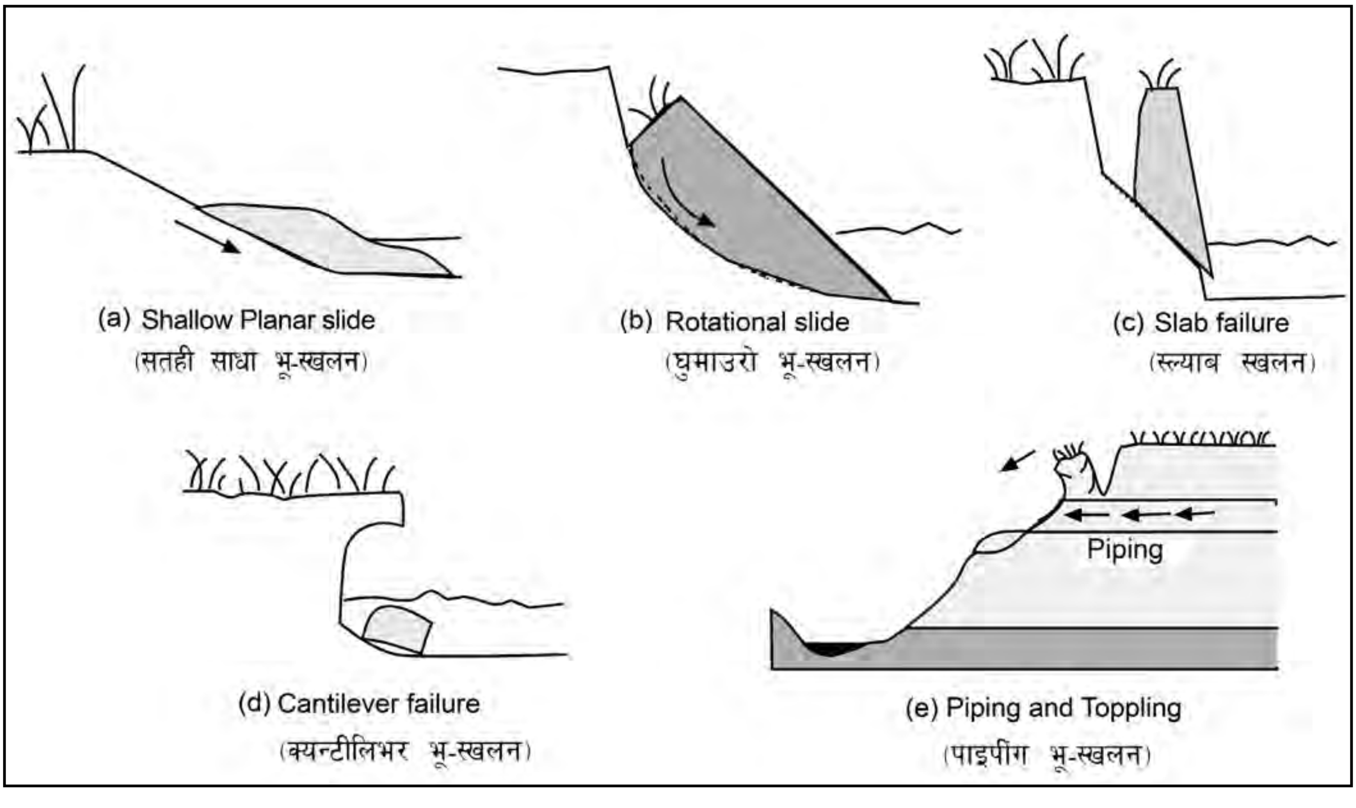
धेरै अग्लो र भिरालो ३५ देखि ६० डिग्री भएका नदी किनार भिरहरू घुमाउरो तवरले स्खलन हुन पुग्दछ (चित्र ४b) । यस्ता भू-स्खलनको टाउको rotate भई slope face तिर ढल्केको हुन्द र curve slip surface सतही पनि हुन सक्दछ (toe facture) अथवा धेरै गहिराईबाट (base facture) पनि हुन सक्दछ ।

(३) **Slab Failure (स्ल्याब स्खलन)**

माटोको ब्लक topple (ढल्काई) किनार तिर झुक्यो भने बिस्तारै नदी तिर सर्दछ । प्रायः ससाना उचाईको तर भीरको कोण (slope angle) धेरै भएका किनारमा slab failure हुने सम्भावना बढी हुन्छ । Slab failure हुनलाई नदीको किनारको हिस्सामा चिरा (Tension cracks) फाट्दछ । त्यस्ता चिराले किनार कमजोर पार्दछ र चिराबाट पानी भित्र पसि माटो अझ कमोलो हुन पुग्दछ । त्यस अलावा पाईपिंग र अरु प्रकृयाले माटोको cohesive बल घटाउँदछ र स्खलन हुन मद्त पुग्दछ ।

(४) **Cantilever Failure**

यसप्रकारको भू-स्खलन प्राय: cohesive माटोमा भएको पाईन्छ । नदीले किनारको आधारमा खियाएपछि माथिल्लो आड नपाएको हिस्सा तल झर्ने वा स्खलित हुने गर्दछ (Thorne and Torey, 1981) (चित्र ४d) ।



चित्र ४: भूस्खलनका विभिन्न प्रकृया ।

(५) **Piping Failure (पाइपींग भूस्खलन)**

नदी किनारको बालुवा अत्याधिक seepage दबावका कारण बालुवा बगेर गई पाइपींग भूस्खलन हुन पुग्दछ (चित्र ४e) । पाइपींग भूस्खलनले तल्लो सतहको आड हटाउने भएकोले माथील्लो भू-सतही माटोको स्खलन गराउन मद्त पुग्दछ ।

(६) **Wet Flow**

माटो तरलीकरण भई बगेपछि भूस्खलन हुन पुग्दछ । बर्षाको समयमा माटोमा धेरै पानीको दबाव (pore water pressure) अत्याधिक वृद्धि हुन गई त्यसबेला माटोको घर्षने शक्ति (shear strength) ह्रास भई तरलीकरण हुन्छ र त्यसकारण भूस्खलन हुन पुग्दछ । यसबाहेक

भूकम्पन हुँदा पनि माटोको कण हल्लिएर shear strength ह्रास भई तरलीकरण हुन्छ।

(७) **Creeping**

पहिरोको एउटा प्रकार मध्ये भू-सराई (creeping) पनि एक हो। भू-सराई धिमी गतीमा चाल नपाउने तवरले भईरहेको हुन्छ। यो खासगरी गुरुत्वाकर्ण बल लागेर नदी किनारिय भूभाग भीरको उपल्लो हिस्साबाट तल्लो हिस्सा तिर बिस्तारै सर्दै जाने प्रकृया हो। नदी कटानले तल्लो भीरको आड खियाएर creeping हुन मद्त पुर्‍याउँदछ।

(८) **भूधस्साई**

भूधस्साई प्रायः भूमिगत जल अत्याधिक मात्रामा निकाली प्रयोग गरेमा भूमिगत सतहको माटोको छिद्रा खाली रहन गई माटो थिच्चिएर हुन पुग्दछ। यदि नदी किनार क्षेत्रका माटोमा चुनढुंगाका बालुवा वा ग्राभलले बनेको छ भने कालन्तरमा अम्ल पानीले घुलेर गई ठाँउठाँउमा vugs तथा भूमिगत गुफाहरू निर्माण भएपछि भूमिगत हिस्सामा आड नपाएर धस्सिन जान्छ। यस अलावा भू-कम्पन हुँदा पनि जमीन कतै चर्कने र कुनै हिस्सा तल खस्ने कुनै उठ्ने भई ठाँउठाँउमा जमिन धस्सिन पुग्दछ।

(ग) नदी कटान तथा भूक्षय

नदी कटान तथा भूक्षय dynamic प्राकृतिक प्रकृयामा लिन सकिन्छ किनभने उपल्लो धारबाट तल्लो धारमा बग्ने क्रममा नदीले सेडिमेन्ट मात्रा परीणाम, इत्यादि तथा नदीको भिरको आधारमा दायाँबाया सर्दै सेडिमेन्ट कतै किनारबाट (cut bank) काट्दछ भने कतै किनारमा थुपार्दछ (convex bank, point bar)। यस प्रकृया अथवा नदीको concave bank काट्ने दर नदीको शक्ती र नदी किनारका ढुंगा, बालुवा वा माटोको गुणमा भरपर्दछ (Rosgen 2001)। नदी कटान र भू-क्षय हुनुको प्राकृतिक कारणहरूः

(क) धेरै मात्रामा वा लेभेलमा नदीमा सतही पानीको बहाव भएमा

(ख) राम्ररी नथिच्चीई खुकुलो माटो वा बालुवाले बनेको किनार भएमा

(ग) किनारिया माटो, बालुवाको क्षयीकरण (weathering) इत्यादि भएमा

नदी कटान र भू-क्षय हुनुका मानव सृजित कारणहरू निम्न बमोजिम छन्ः

(क) भूप्रयोगमा परिवर्तन आएमा

(ख) धेरै चढन गरेमा

(ग) बानस्पतिक विनाश भएमा

(घ) नदी अतिक्रमण भएमा

(ड) नदीमा खानी संचालन गर्नाले

नदी किनारको बनोट र त्यहाँ परिरहने बहावको आधारमा मोटामोटी रूपमा नदी कटान र क्षयी प्रकृयालाई ३ भागमा बाँड्न सकिन्छ। जस्तैः

(क) आकाशिय भूक्षयीकरण (Sub-aerial erosion)

(ख) जल भूक्षयीकरण (Sub-aqueous erosion)

(ग) नदी कटानबाट हुने भूक्षय

आकाशिय भू-क्षयीकरणः पानीको सतही बहाव भन्दा उपल्लो हिस्सामा विभिन्न प्रकृयाहरू परिचालन हुन्छन्। यस हिस्सामा रहेका वाटो बालुवा घामले सुक्ने र चर्कने, वर्षातको पानीको थोपाले माटो खुकुलो हुने, सतही बहावको लेभलमा परिवर्तन भईरही सुख्खा र ओश निरन्तर चक्रीय रूपमा भएमा माटो डल्ला डल्ला भई फुट्ने प्रकृया (slaking) तथा हुरिबतासले पनि बिरुवा वा रुख हल्लीएर माटो खुकुलो हुने, इत्यादि पर्दछन्। पाइपींग, धर्के भूक्षयीकरण, खोल्से भूक्षयीकरण तथा पत्रे भूक्षयीकरण (sheet erosion) इत्यादि पनि आकाशिय क्षयी प्रकृयामा पर्दछन्। यी सबै प्रकृयाले नदी किनार कुनै न कुनै तवरबाट कमजोर भई फिल्के बाढी आउने बेला सजिलै सित पखालिएर जान सक्दछ। आकाशिय क्षयी हुनुमा मुख्यतयाः सतही पानीको बहावमा तल माथी भईरहनु, वानस्पतिक विनाशका कारणले माटो खुकुलो हुनु, पशुचरण अत्याधिक हुनु तथा अन्य कारण हुन्।

जलीय भूक्षयीकरणः (subaqueous erosion)

नदीको बहावले सतही पानीको तल्लो हिस्साको किनारलाई खियाउँदै जाने (scouring) प्रकृया मुख्यत जलीय भूक्षयीकरणमा पर्दछ। जब नदीको धारले बहन गर्ने शक्ती नदी किनारिय माटो, बालुवा स्थिर रहने शक्ती भन्दा बढी हुन पुग्दछ। Scouring कत्तिको हुन्छ भन्ने कुरा नदी किनारिय माटो वा बालुवाको घस्रने चाप (Near bank stress (NBS)) ले देखाउँदछ। NBS आफै पनि सतही पानीको गहिराई र नदीका भू-घरातलीय भिर (slope) मा निर्भर गर्दछ। Scouring ले फिल्के बाढीको निरन्तरता र क्षमता देखाउँदछ।

(घ) नदी बहावमा ह्रास तथा फिल्के बाढी (Flash Flood)

नदी बहावमा ह्रास हुने तथा फिल्के बाढी आउने प्रकृयाहरू मौसम र मानव सिर्जित असरमा भरपर्ने प्रकृयाहरू हुन्। मौसमी र मानव असरबाट प्रभावित हुने क्षेत्रमा कुनै जलाशय जहाँ वर्षातको मात्रा कालान्तरमा घटेको छ र मानवले श्रोतबाट पानी बढी प्रयोग गरेको अथवा पाईपलाईनबाट खानेपानीको लागि खिचेको छ त्यस्तो जलास भएर बग्ने नदीमा अप्राकृतिक रूपले नदीको क्षमता, बहाव र लेभल घट्दै जान्छ। जस्तैः अहिलेका अधिकांश वागमतीका नदी नाला। Shrestha and Tamrakar (2013) को आधारमा काठमाडौं उपत्यकाको बागमती जलाशय भेगमा वर्षाको प्रक्षेपण सन् १९७५ देखि २०१० सम्म घट्दो छ। पानी अत्याधिक खिचिएको हुनाले अरुबेला सुस्त बग्ने हुन्छ। तर बर्षातको बेला एक्कासी नदीको क्षमता र बहावमा वृद्धी हुन गई ठाँउठाँउमा पानीले घर खेतमा असर पुर्‍याउँदछ। यसरी असर पुर्‍याउनुको कारण नदीलाई भनभन सांधुरो बनाउँदै पर्खाल निर्माण गरी त्यस छेउ बाटो बनाउनाले हो। धेरै वर्षा भई बहाव बढेको बेला नदीले पानी थेग्न नसकी आफ्नो धारबाट पोखिने प्रवित्ती हुन्छ।

मनसुनमा प्राय ८०% जसो बर्षात हुने हुँदा नदीले बहाव गर्ने सेडिमेन्ट र सतही जल फिल्के बाढीको रूपमा प्रवाह हुने गर्दछ र होंचो सतह वा नदीको flood plain मा पानीबाट ढुवान हुन पुग्छ। नदी किनार क्षेत्रमा बसोबास भएका ठाँउमा फिल्के बाढीले असर पुऱ्याउन सक्दछ। फिल्के बाढीले जमिन डुवान गर्ने, बस्ती, खेतबारी तथा कलकारखाना र अस्पताल इत्यादिमा समेत पुर्‍याउँदछ र कतिपय बेला मानिस र पशुको ज्यान समेत जान सक्दछ। फिल्के बाढीले असर पुर्‍याउन सक्दछ कि छैन भनेर जोखिम नक्शांकण गर्नु उचित हुन्छ। वस्ती विकाश तथा ठुलो संरचना निर्माण गर्नु अगावै यस्ता नक्शा हेरेर सुरक्षित ठाँउमा, अलि नदी किनार भन्दा टाढा जुन ठाँउमा बाढी आउँदाखेरी बाढी ग्रस्त लेभल (flood prone level) (चित्र ५) सम्मपुग्न सक्दैन ती अग्लो र टाढा भेगमा निमार्ण गर्नु पर्दछ। यो एक प्राकृतिक प्रकृया हो जुन मौसममा निर्भर गर्दछ। फिल्के बाढीको स्वरूप कत्तिको ठूलो वा सानो हुन्छ भन्ने कुरा नदीको बहावको मात्रा, नदीको पानी थेग्ने क्षमता, इत्यादिमा भर पर्दछ।

जोखिम न्यूनिकरणका चुनौतीहरू

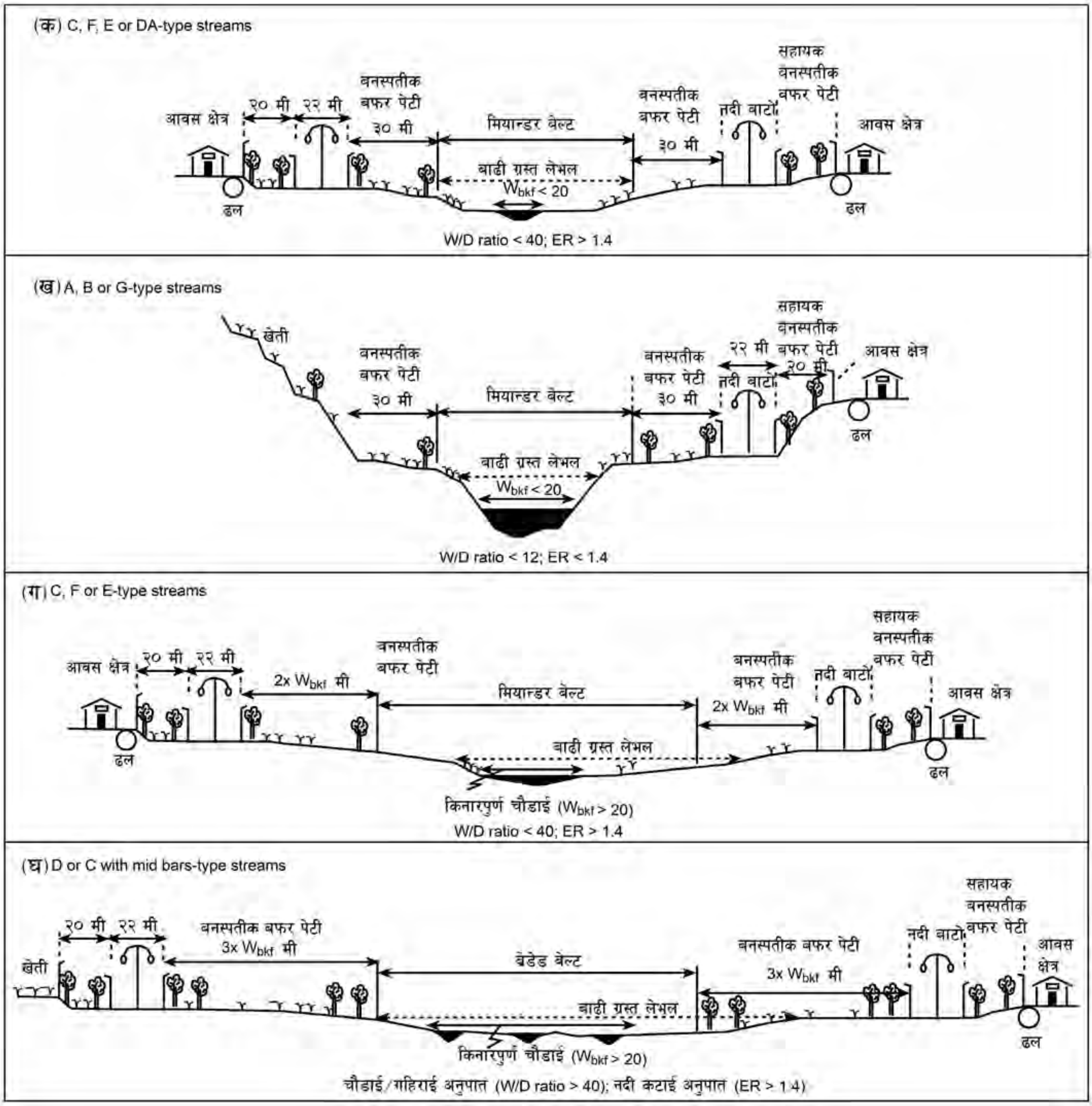
प्राकृतिक प्रकृया तथा तिनबाट हुने प्रकोप निरन्तर प्रकृया भएको हुनाले तिनलाई रोक्न सकिँदैन तर तिनबाट हुने जोखिम र क्षती न्यूनिकरण गर्न सकिन्छ। यद्यपी जोखिम न्यूनिकरणमा धेरै चुनौती छन्।

(१) नदी किनार क्षेत्रमा प्रायः नया माटो तथा फोहर का पूरन (fill) छन्। ती

माथी बाटो, घर, टहरोको अव्यवस्थित निर्माण भैसकेका छन् । त्यस्ता क्षेत्र भूकम्पीय दृष्टिकोणबाट मात्र नभई भूस्खलन तथा भूक्षयीको दृष्टिकोणबाट समेत जोखिमपूर्ण छन् (चित्र ६) । त्यस्ता पूरन माथी बनेका संरचनालाई व्यवस्थित गरी जोखिम न्यूनिकरण गर्ने कुरा चुनौतीपूर्ण छन् ।

(२) नदी किनार क्षेत्रका माटो बालुवा खुकुलो, कम घनत्वको र कमसल बलका हुन्छन् । त्यस्ता भू-बनोट भएका ठाउँमा भूकम्पन बढी हुने गर्दछ । जसबाट बालुवाको तरलीकरण भई संरचनाको क्षती अन्यत्र भन्दा बढी हुन सक्दछ (चित्र ६) । त्यतिमात्र नभई माटो बालुवाको बलको गुण कमसल भएकाले नदीको बहावबाट कटान छिट्टै हुन सक्दछ । त्यस्ता नदी किनारका भू-बनोटमा जोखिम न्यूनिकरण कार्य चुनौतीपूर्ण छन् ।

(३) नदी किनार क्षेत्रमा नदीको मियान्डरबेल्ट छुट्याई नदीको करिडोर क्षेत्र निर्धारण गराई नदी करिडोरको भू-व्यवस्थापन गर्ने काम धेरै चुनौतीपूर्ण छ (Tamrakar 2010) । भू-व्यवस्थापन अन्तर्गत नदी किनार क्षेत्रको



चित्र ५: नदीको वर्गीकरणका आधारमा नदी करिडोरको व्यवस्थित भूप्रयोगको अवधारणा प्रस्तुत गरिएको (Tamrakar 2014). भिल्के बाढीले असर पुर्‍याउन सक्ने नदी किनार क्षेत्रमा मियान्डर बेल्ट र ब्रेडेड बेल्टका साथै बनस्पतीक बफर पेटी पनि पर्दछन् । देखाईएका आवस क्षेत्र भिल्के बाढीले असर पुर्‍याउन नसक्ने भएतापनि भूकम्पीय दृष्टीकोणबाट अति जोखिमपुर्ण छन् ।

बचाव गर्ने, संरक्षण गर्ने र त्यसपछि संस्कृतिक संरचनालाई सुरक्षित बनाउने र अरु अव्यवस्थित वस्ती तथा आवासलाई पूनर्वास दिई मानव र नदीलाई प्रकोपबाट सुरक्षित गर्ने कार्य चुनौतीपूर्ण छन् ।

(४) जलाशयबाट अत्याधिक जलको खिचाईले नदीको बहावमा जुन ह्रास भईरहेको छ त्यसलाई व्यवस्थापन गरी नदीको बहाव नियमित गर्ने कार्य पनि चुनौतीपूर्ण छ ।

(५) कतिपय नदी किनार क्षेत्रमा नदीको बनोट परिवर्तन हुने गरी अतिक्रमण गरी निर्माण गरिएको पर्खाल, बाटो, पुल तथा घरहरू छन् । ती संरचनालाई भत्काई नदीलाई पुनर्स्थापन गरी नदी किनारमा हुने प्राकृतिक प्रकृयाबाट हुने जोखिम न्यूनिकरण गर्ने कार्य पनि चुनौतीपूर्ण छन् ।

चित्र ६: नदी करिडोर क्षेत्रमा घटेका प्राकृतिक प्रकोप तथा प्रकृया। (क) गोंगबुं बसपार्क नजिकै मिती २०७२/१/१२ मा गएको भूकम्पबाट बालुवामाटो तरलीकरण भई घर धस्सिएका दृश्य, (ख) २०७२/१/१२ मा गएको भूकम्पबाट कौशलटारमा चिरा फाटेको दृश्य, (ग) कोड्कु नदी किनारमा झिल्के बाढीले कटान भई भूक्षय भएको दृश्य र (घ) नख्खु नदी किनारमा भूक्षय (cantilever bank failure) भएको दृश्य ।

निष्कर्ष:

काठमाडौं उपत्यकाका नदी किनार क्षेत्र अति नै अव्यवस्थित छन् । मानव निर्मित संरचनाहरूले नदीलाई अतिक्रमण र प्रदुषण गरेका छन् । फोहर र माटो पुरन तथा नदी आफैले बगाई थुपारेको माटो बालुवा खुकुलो, कम घनत्वको र कम बल गुणको हुनाले भूकम्पीय, भूस्खलन र भूक्षयको दृष्टिकोणबाट बढी प्रभावित हुन्छन् । निरन्तर भईरहने प्राकृतिक प्रकृयाहरू नदी वातावरणको एक प्राकृतिक हिस्सा हो । त्यसलाई रोक्न सकिन्दैन तर तिनबाट हुने जोखिम न्यूनिकरण गर्न सकिन्छ । यसकालागि नदी करिडोर क्षेत्रको व्यवस्थापन सँग करिडोर क्षेत्र निर्धारण, नदी पुनर्स्थापन तथा अव्यवस्थित संरचनाको पुनर्वास गरी नदी करिडोर क्षेत्रमा संरचनाको निर्माण सिमीत गरी त्यस क्षेत्रलाई बनस्पतिक पेटीको रूपमा विकास गर्ने कार्यहरू यथा शिघ्र गरिनु पर्दछ । निर्माण गरिने विकास निर्माणका संरचना भूकम्पीय प्रतिरोधात्मक हुनुपर्दछ । यद्यपी माटोको गुण कमसल भएकाले नदी करिडोर क्षेत्र सकेसम्म मानव बस्ती रहित बनाउनु पर्दछ ।

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Towards the early warning system of rainfall-induced landslides in Nepal

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ABSTRACT

In the Himalaya, people live in widely spread settlements and suffer more from landslides than from any other type of natural disaster. The intense summer monsoons are the main factor in triggering landslides. Landslides in the Himalaya are scale-dependent, from massive extent of whole mountain ranges (gravity tectonics) through failure of single peaks to very minor slope failures. In early 2008, considering rainfall as a main factor triggering landslides in Nepal, Dahal and Hasegawa (2008) established relationships between landslide occurrence and rainfall characteristics, i.e. rainfall threshold for landsliding in the form of empirical equations. Dahal and Hasegawa (2008) described rainfall threshold for Nepal in two different approach: intensity-duration threshold and normalized rainfall intensity threshold. Taking reference of these two thresholds, two models of early warning systems (RIEWS and N-RIEWS) are proposed in this paper. All the experts involving in the hydro-meteorological issues of the Nepal Himalaya are highly welcomed to criticise the model and operational procedure described in this paper. All the constructive comments will certainly enhance the proposed early warning procedure.

LANDSLIDES IN NEPAL

The Himalayan mountain chain measures 2400 km in length and is one of the tectonically most active mountain ranges on the earth. Rugged topography, unstable geological structures, soft and fragile rocks, common earthquakes, along with heavy and concentrated rainfalls during monsoon periods cause severe landslides and related phenomena in the Himalayan region. In Nepal, for example, in only the half monsoon period (i.e., from June 10 to August 15) death toll due to the landslides is more than 50. In 2007, landslide death toll in the half period of monsoon was 70, where as in 2008 and 2009, the tolls were 50 and 68, respectively. In 2015 monsoon, the death toll from landslide is already more than 80.

The small-scale rainfall-triggered landslides in Nepal are generally shallow (about 0.5 to 2.5 m thick) and are triggered by changes in physical properties of slope materials during rainfall. Relatively large-scale and deep-seated landslides, on the other hand, are affected by long-term variation in rainfall. Annual monsoon rainfall in Nepal ranges from as low as 160 mm in the northwestern region to as high as 5,500 mm in some isolated areas of central Nepal. However, mean annual rainfall of 1,500–2,500 mm predominates over most of the country. More than 80% of the total annual precipitation occurs during the summer four months (June–September). Likewise, the distribution of daily precipitation during the rainy season is also uneven. Sometimes, 10% of the total annual precipitation can occur in a single day (Alford, 1992), and 50% of the total annual precipitation is often recorded within 10 days of the monsoon period.

Many research papers and reports dealing with Himalayan landslides mainly focus on loss of life and wealth, physical properties of landslides and debris flows, effects of regional and local geological settings, hazard analysis and recommendations for environmental-friendly preventive measures. Dahal and Hasegawa (2008) established rainfall threshold for landslides in the Nepal Himalaya. Depending on findings of Dahal and Hasegawa (2008), the main objective of this paper is to explore a suitable procedure of early warning of rainfall-induced landslides in Nepal.

RAINFALL THRESHOLD FOR LANDSLIDE IN NEPAL

Geomorphology, geology, and climate play the most important role in preparatory process of landslide initiation in any region. With 83% low to high mountainous area, Nepal covers approximately one third of the Himalayan mountain ranges in the central Himalaya. It is often said that wet monsoon over the Himalaya is responsible for almost 90% of South Asian water resources. Orographic effects are the main cause of monsoonal rainfall in Nepal, which usually begins in June and ends in September. This effect is largely dependant on the topography. For example, the southern part of central Nepal is gentler than the other parts but rises abruptly in the north to form steep Himalayan peaks like the ranges of Dhaulagiri, Annapurna and Manaslu (Fig 1). As a result of the orography of these ranges, the Pokhara area on the south generally gets much higher rainfall than the other parts of Nepal. For this reason, central Nepal has high values of mean annual rainfall and extreme 24-hour rainfall.

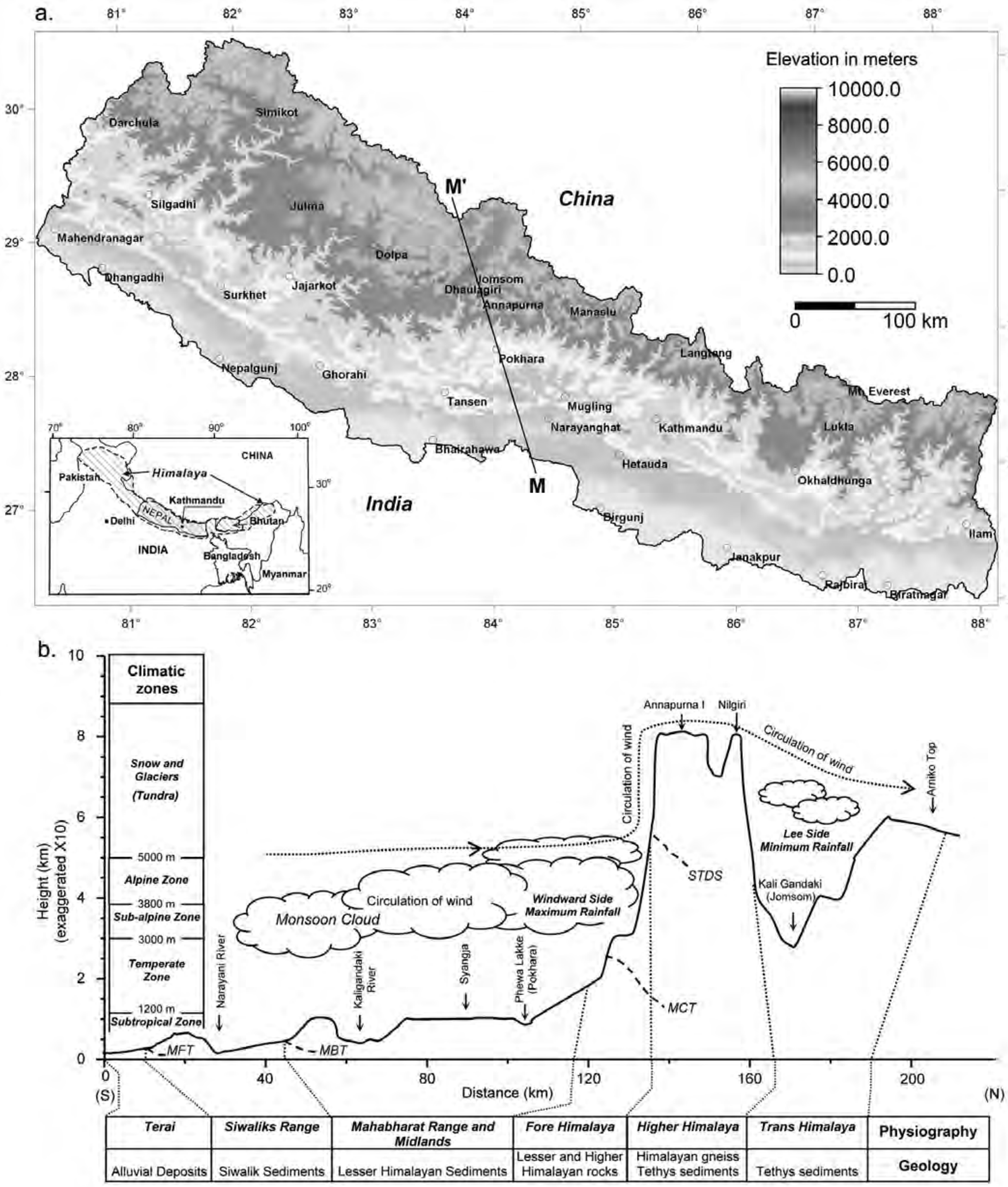

Fig. 1: a) Relief map of Nepal, a lower altitude area is situated in the area between west of Kathmandu and Pokhara. b) A topographical profile through line MM' in Fig 1a with illustration of climatic zones, main geology and regional geomorphology, example from Narayanghat-Pokhara-Jomsom section. Because of strong orographic effects of abruptly elevated mountains of North, central Nepal gets torrential monsoon rainfall.

Until 2007, for the Himalaya, no generalized studies exist for landslide and debris-flow initiating precipitation thresholds although these mountains have tremendous landslide problems compared to other parts of the world. Considering rainfall as a main factor triggering landslides in Nepal, Dahal and Hasegawa (2008) have established relationships between landslide occurrence and rainfall characteristics in the form of empirical equations. The empirical thresholds refer to relational values based on statistical analysis of the relationship between rainfall and landslide occurrences (Campbell, 1975; Caine, 1980; Larsen and Simon, 1993; Guzzetti et al., 2004), whereas physical thresholds are usually described with the help of hydrologic and stability models that take into account the parameters such as relationships between rainfall and pore-water pressure, suction, infiltration, slope morphology, and bedrock structures (Montgomery and Dietrich, 1994 and Terlien, 1998). Dahal and Hasegawa (2008) considered 193 landslide events through 55 years (1951–2006) for establishing rainfall threshold relationships. The method employed by Dahal and Hasegawa (2008) in establishing the rainfall thresholds is similar to that by other researchers (e.g., Caine, 1980; Cancelli and Nova, 1985; Larsen and Simon, 1993; Aleotti, 2004; Guzzetti et al. 2007) for such estimations in different parts of the world.

Dahal and Hasegawa (2008) described rainfall threshold for Nepal in two different approach: intensity-duration threshold and normalized rainfall intensity threshold. They defined intensity-duration threshold as:

$$I = 73.90D^{-0.79} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (1)$$

where I is hourly rainfall intensity in millimeters (mm hr^{-1}) and D is duration in hours.

Dahal and Hasegawa (2008) also analyzed the landslides and the corresponding rainfalls respect to the mean annual precipitation (MAP), which is another approach to rainfall-threshold analysis (Jibson 1989; Aleotti, 2004; Guzzetti et al., 2007). The ratio between the critical rainfall of the event and the mean annual precipitation of the site is defined as normalized critical rainfall (NCR), and it is expressed in. By normalizing rainfall intensity with NCR, Dahal and Hasegawa (2008) expressed following threshold for landslides in Nepal:

$$NI = 1.10D^{-0.59} \quad \ldots\ldots\ldots\ldots\ldots.. (2)$$

where NI is normalized rainfall intensity (hr^{-1}) and D is duration in hours.

LANDSLIDE WARNING SYSTEMS BASED ON RAINFALL THRESHOLDS

The increasing number of the temporal recurrence of natural disasters, such as landslides, shows that disastrous events occur with a frequency higher than the social and economical ability of a country to recover from previous events. Both developed and developing countries are less easer to invest in mitigation measures owing to the huge cost and direct impact on functional development of the county. As a result, many countries are now interested to develop early warning system as well as land utilization regulations for minimizing the loss of lives and property damage without investing in mitigation measures. Adversely, a developing country like Nepal still does not have any such concept and every year more than 300 people killed by natural hazards.

In Nepal, rainfall threshold and warning system usually haves some limitations with rainfall data. Most rainfall stations in Nepal are of non-self recording type, so only 24-hour data, and no hourly data are available. The Department of Hydrology and Meteorology (DHM) measures rainfall data at 8:45 AM each day and records it as the rainfall of that day. A few automated rainfall recording stations also exist, but the data are not for public access. Officially, it is still unclear that how many stations are automatic in Nepal. During this work, DMG was asked for some information about automatic stations and unfortunately, information could not obtain. Thus, in this research, all analyses were done on the basis of available daily rainfall data only.

Nepal still does not have any concept of early warning and every year more than 300 people killed by natural hazards. In Nepal, rainfall threshold and warning system usually haves some limitations with rainfall data. Any of the rainfall thresholds described by Dahal and Hasegawa (2008) can be utilize for development of warning thresholds for early warning systems.

Conventionally, when rainfall intensity-duration is considered as basic parameters of rainfall threshold for landslide interpretation, whole monsoon rainfall can be plot in the form of temporal pattern of rainfall intensity vs. rainfall duration curve (Aleotti, 2004) as shown in Fig 2. The threshold line (TL) in Fig 2 represents Eq (1). The curve can be plot from daily rainfall data of monsoon period. When temporal rainfall intensity (TRI) is used, some none rainfall days also can be considered and as a result, curve shows negative trend of rainfall advancement (Fig 2a). Similarly, time of early warning usually appears when TRI curve trends to move near to the threshold line. Thus, for the consideration of early warning time, a warning threshold line (WTL) needs to be defined in Fig 2. Similarly, when critical time for evacuation is already fixed, warning threshold curve (WTC) can be prepared. Likewise, when TRI curve meet WTL or WTC, early warning information should be imposed in the area. In Fig 2a, five cases of TRI curves are illustrated to describe various patterns of rainfall and hypothetical landslide scenario. Fig 2b represents the condition described in Fig 2a in the real data. Fig 2b well illustrates the possible early warning for rainfall and landslide incidence and this is the one short of verification of model described in Fig 2a. Likewise, when normalized rainfall intensity is considered for early warning, similar model can be developed with consideration of Eq. (2). For ease of usage, the rainfall intensity-duration model and the normalized rainfall intensity-duration model are named a RIEWS (rainfall intensity based early warning system) and N-RIEWS (normalized rainfall intensity based early warning system).

Early warning model described here show less time for evacuation in the case of short duration and high intensity rainfall, whereas for long duration rainfall, warning time is enough and when warning information disseminate to the people, people will aware to possible landslide risk. In the meantime, they will be mentally ready to tackle with possible disaster of coming hours or days and will avoid the consequences. On the basis of coarse hydro-meteorological data of developing country like Nepal, this simple and rather easy model of early warning will certainly help to reduce fatalities from landslides.

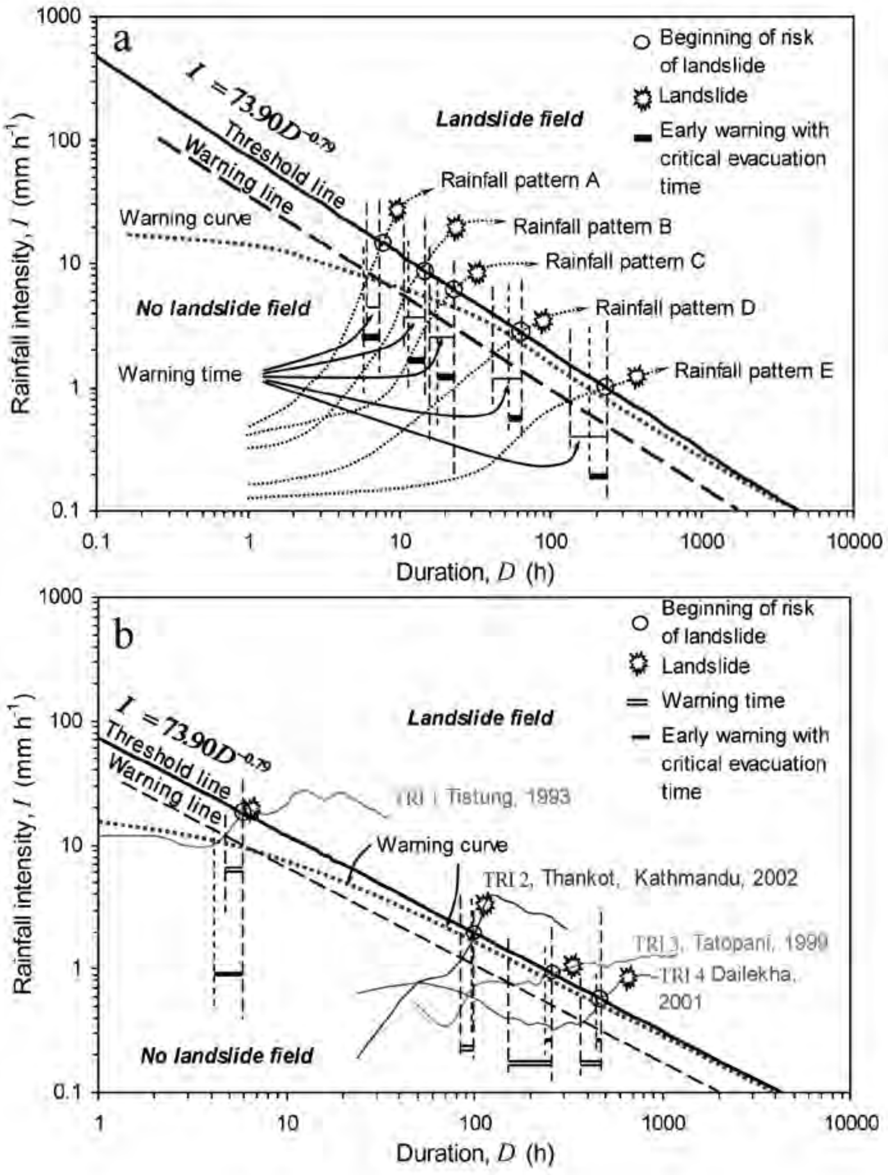

Fig. 2: a. Early warning model for rainfall-induced landslides in Nepal based on rainfall intensity-duration data (RIEWS model), b. Implementation of RIEWS model for previous rainfall and landslide data.

There are few automatic stations in Nepal which record hourly rainfall. Similarly, NASA and the Japan Aerospace Exploration Agency (JAXA) have started a joint mission named as Tropical Rainfall Measuring Mission (TRMM) to monitor tropical rainfall including monsoon of south Asia. A new series of quasi-global, near-real-time, TRMM-based precipitation estimates is now available to the research community. TRMM for the first time is providing accurate estimates of the rainfall over the strong-monsoon areas. TMPA (TRMM-based Multi-satellite Precipitation Analysis) precipitation data are available in both real-time and post-real-time versions, which are useful to assess the location and timing of rainfall-triggered landslide by monitoring landslide-prone areas while receiving heavy rainfall (Hong et al. 2006). Thus, for the high intensity rainfall condition of short duration (rainfall patterns A and B in Fig 3), it is strongly recommended to use hourly data of few rainfall gauging station and data from remote sensing satellite such as TRMM. Without such information, early warning of landsliding related to short duration high intensity rainfall is not possible.

A suitable flow chart of implementation of RIEWS or N-RIEWS model is shown in Fig 3. This proposed proto-type early warning system is purely an interdisciplinary work and it need combine efforts of engineering geologist, geotechnical engineer, meteorologist, remote sensing expert and disaster management expert. Flow chart clearly shows that preparation of temporal rainfall intensity curve is a very important stage for implementation of early warning models proposed in this paper. It means data of every day rainfall should be available to early warning team.

Available geological information along with 3D terrain views available in free internet resources, such as Google Earth, will certainly assist to geomorphologist for evaluating geomorphological settings of the area of risk. Meantime, communication media like FM radio stations, Nepal Telecom SMS service in mobile phone as well as community based siren system can be the best suitable method to spread warning to the people at risk. There are nearly 150 FM radio stations in operation in the different part of Nepal and they can play very effective role for information dissemination. Once awaiting disaster is known, civil security services can be also mobilized into the area of high risk and thereby people will get enough support for evacuation and livelihood.

There lacks many information about the capability of

DHM, especially for hourly rainfall data and use of real time satellite data in current meteorological forecast. Many attempts were made to collect the information about these issues but never succeeded because of many unseen technical difficulties. All the experts involving in the hydro-meteorological issues of the Himalaya are highly welcomed to criticise the model and operational procedure described in this paper. All the constructive comments will certainly enhance the proposed early warning procedure.

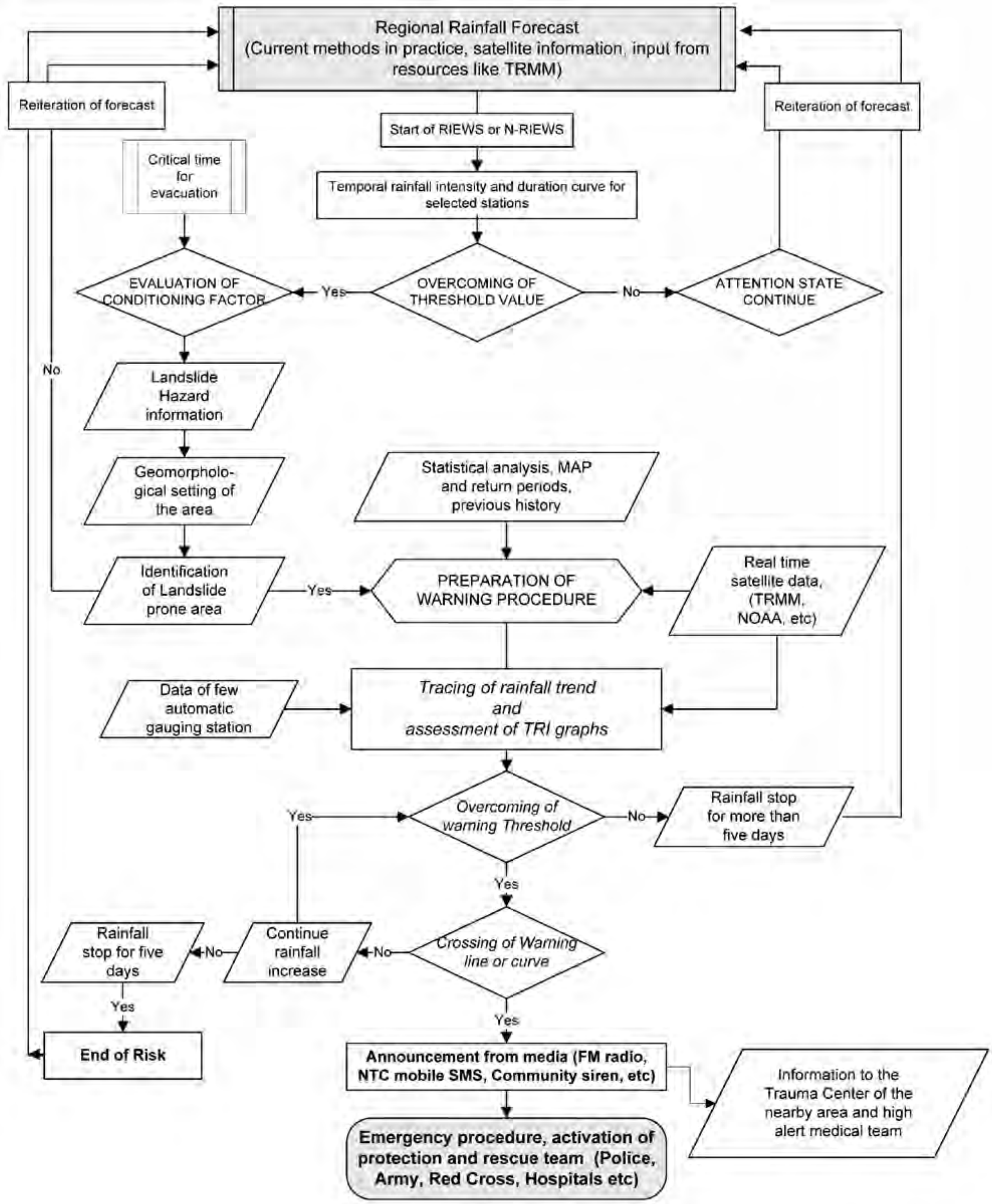

Fig. 3: Operating procedure of RIEWS and N-RIEWS type landslide early warning models.

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Importance of Watershed Atlas in Watershed Management Activities

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Abstract

Watershed atlas plays an important role in watershed management planning including watershed prioritization. The atlas serves as an basic tool for initiating watershed management planning by the concerned agencies. However, watershed atlas of Nepal is not available till date. Various data is required for the preparation of the watershed atlas, which may be primary or secondary. Preparation of watershed atlas of the country requires significant resource and time. This paper emphasizes the need of preparation of watershed atlas of the country with watershed management perspective in the country. The data required for the preparation of watershed atlas has been discussed and sample maps of watershed atlas has been presented.

THE WATERSHED ATLAS

Watershed Atlas is a colour book of maps, statistics and text about the major watersheds in the country. Watershed Atlas is a basic planning tool for watershed management. It incorporates database at river basins, sub-basins and watershed scale. Watershed Atlas covers bio-physical and socio-economic elements of the watershed in various layers of maps and linked statistical data files.

WATERSHED MANAGEMENT

It is the process of creating and implementing plans, programs, and projects to sustain and enhance watershed functions that affect the plant, animal, and human communities within a watershed. The various components of watersheds that need to be managed include water supply, water quality, drainage, runoff, water rights, disaster mitigation etc.

A watershed includes the human as well as the natural system with their various elements and interrelationships. The human system represents the social sphere whereas the natural system represents the landscape sphere. The changes in one element can have significant implications in the structure and function of the other elements.

The human system may affect the watershed either by influencing the priorities of the residents or constraining the financial resources available to resolve watershed issues. The natural system, on the other hand provides the resources necessary for sustaining human livelihoods and development. It comprises of the interacting biotic elements (living components of the environment) that affect ecological functions and abiotic elements (non-living components of the environment, such as rock, soil, climate and water resource), which are interlinked and connected by cycles and a flux of energy, materials and organisms. These interactions and natural processes that link these biotic and abiotic elements characterize the natural system and functions as watershed ecosystem dynamics. The watershed is characterized by various elements like topography and landforms, geology, soil, water resources, vegetation, biodiversity, animals and climate. Recently, the watershed management has been considered as important approach for natural resources management, especially in water resources management.

WATERSHED MANAGEMENT IN NEPAL

Construction of terraces in the mountain landscape since historical time is an excellent example of watershed management in Nepal. When the population pressure coupled with scarcity of arable lands, the necessity of appropriate upland watershed management was realized in Nepal in the 1960s. It was due to the encroachment of highly erodible sloping lands resulting in the frequent occurrence of landslides. Thus, the watershed management programme was initiated by the Department of Forests under the Ministry of Forests in 1966. The project entitled 'Survey and Demonstration for the Development and Management of the Trishuli Watershed - A Pilot Project'. In 1974 Government of Nepal (then His Majesty's Government of Nepal) established Department of Soil Conservation and Watershed Management (DSCWM) (then the Department of Soil and Water Conservation) under the Ministry of Forests and Soil Conservation (then the Ministry of Forests).

Between 1974 and 1982 the department collected various information related to soil erosion and watershed management through various projects. Previously, the approach was top-down. Planning, implementation and monitoring of watershed management activities used to be done from the central level. However, this approach couldn’t yield anticipated result. This was mainly due to negligible consideration of people's participation and users' group approaches.

In the recent time, the watershed management programs have been implemented with the people’s participation that are showing encouraging results. However, much effort is needed to cope with nation-wide problems. In addition, possibilities

need to be explored for co-operation and collaboration among key stakeholders who take advantage of watershed resources. Recently, Government of Nepal has realised and acknowledged the need of "basin approach" for the effective soil conservation and watershed management in the country.

DATA REQUIRED FOR WATERSHED ATLAS

The main data required for the preparation of watershed atlas could be the following:

- River basin, sub-basin and watershed area demarcation.
- Climate: Rainfall, temperature
- Topography: Elevation, slope
- Geology: Rock type, soil type, major geological structures
- Land cover: Areas covered by agriculture, vegetation, settlement/built up and water bodies etc.
- Watershed degradation: Landslide, gully erosion
- Infrastructure: Road network, hydropower stations, industries, school/college etc.
- Socio-economic: Population, household, literacy, economic condition etc.
- VDCs with major settlements falling within the watershed.
- Location of water bodies like streams, lakes/ponds within the watershed boundaries as far as it is mappable.
- Boundaries of conservation areas.
- Population data of CBS within the basin, sub-basin and watershed

The initial task is to delineate basin, sub-basin, watershed. In the case of Nepal the three major basins, namely Koshi, Gandak and Karnali-Mahakali forms major component. The drainage areas of Siwalik and Terai plain that does not fall within any of the three basins can be included within the adjacent basins. This stage can be followed by Sub-basin delineation within the basin and then watershed delineation within the sub-basin. Each basin, sub-basin and watersheds need to be assigned with specific ID's to form standard coding system. For example, to represent Trijuga watershed KTKTG coding system can be used in which, the first letter represents for Koshi Basin (K), the second two letters (TK) represent the Trijuga-Koshi Sub-Basin, the last two letters (TG) is for the Trijuga Watershed. Attribute fields can be created to store various data related to the watershed.

SAMPLE MAPS OF WATERSHED ATLAS

Data of a sample watershed (Trijuga River Watershed) in Koshi Basin has been prepared as part of the content of watershed atlas. Trijuga River watershed falls in the Eastern Nepal that is geologically covered mainly by Siwalik (Churia Region) and partly by the Lesser Himalaya. Various data layers like, topography, geology, land cover, drainage, administrative units etc. should be prepared to be incorporated in the watershed atlas. Some examples of the maps to be part of the watershed atlas are presented below in Fig. 1 to Fig. 8.

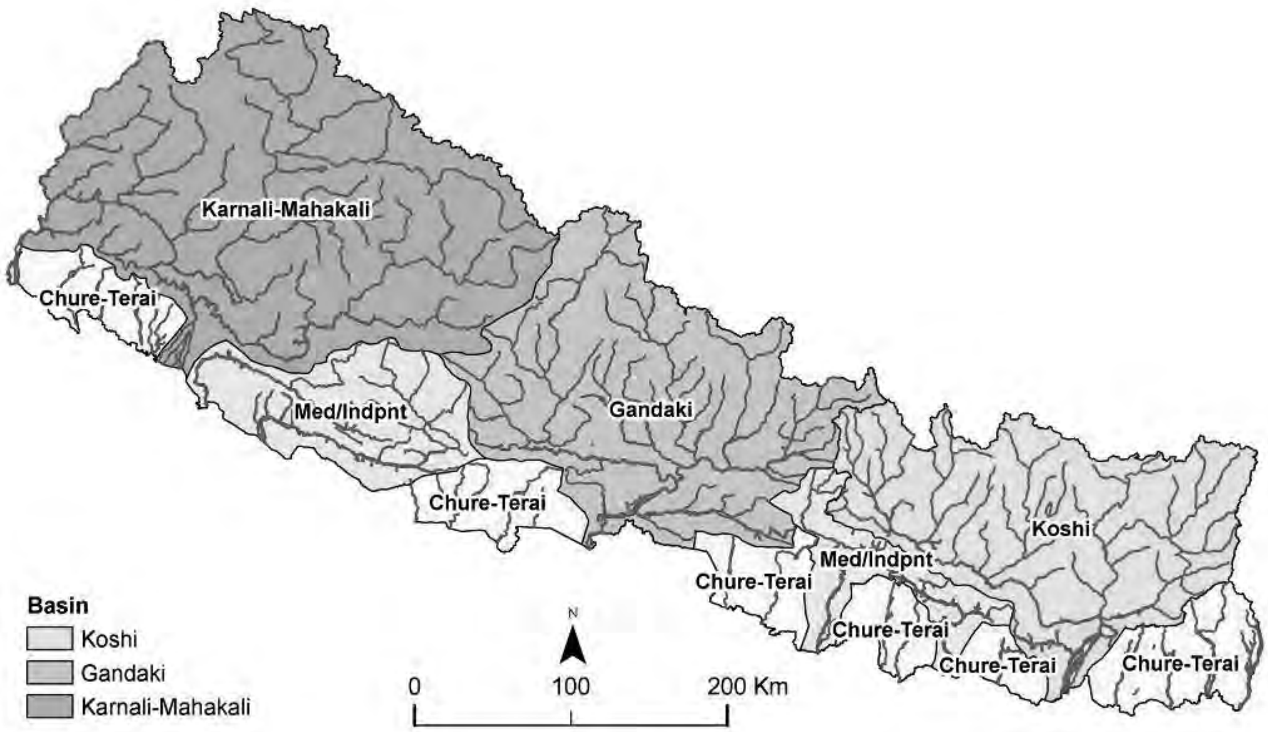

Fig. 1: Major Basins and Sub-Basins of Nepal and location of Koshi Basin.

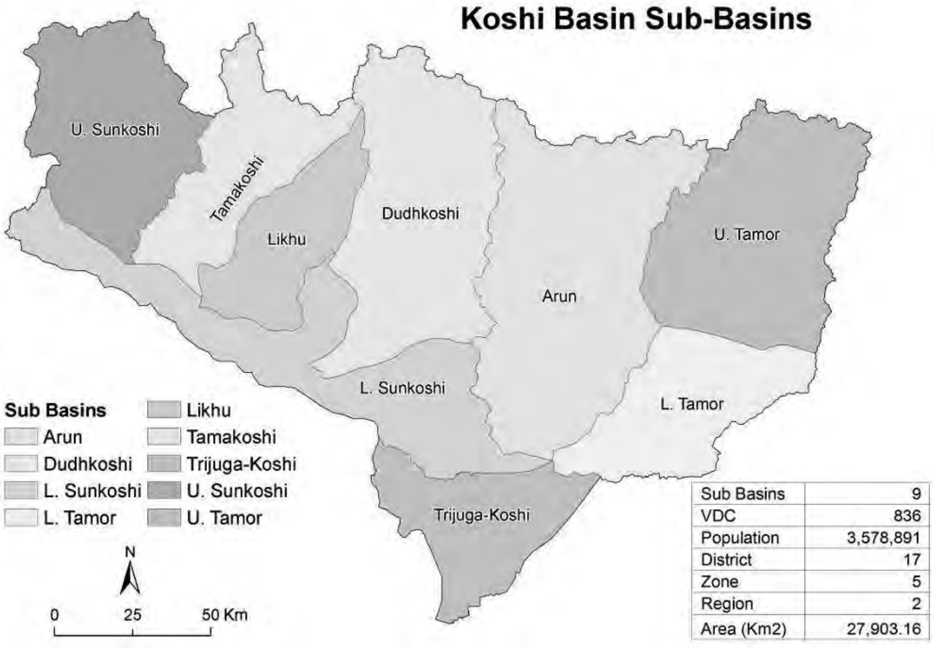

Fig. 2: Sub-Basins of Koshi River Basin.

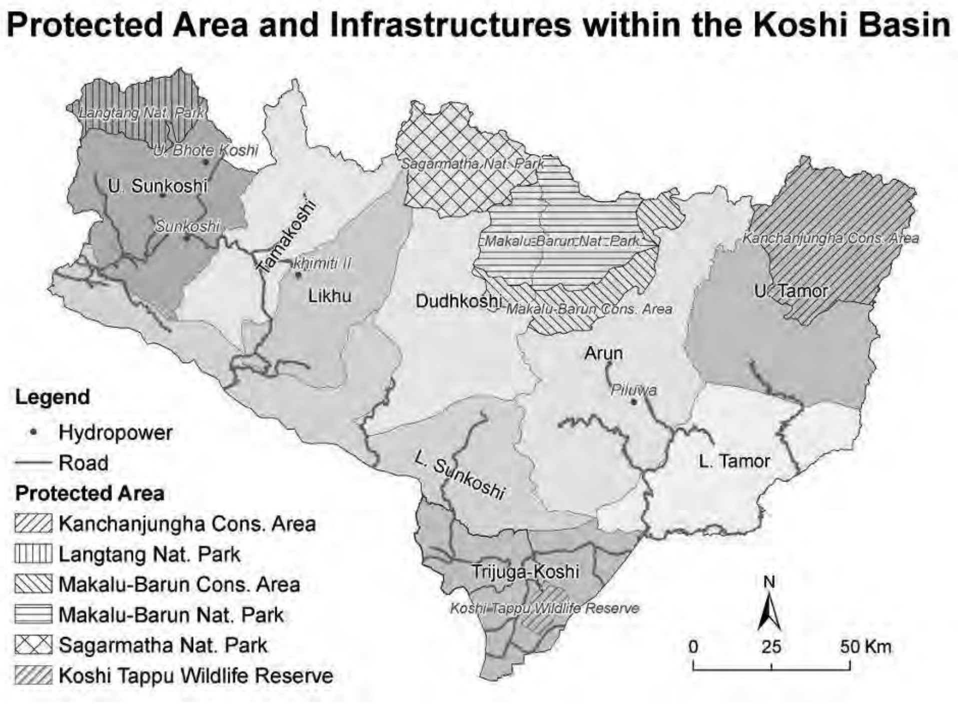

Fig. 3: Protected areas and infrastructures within the Koshi Basin.

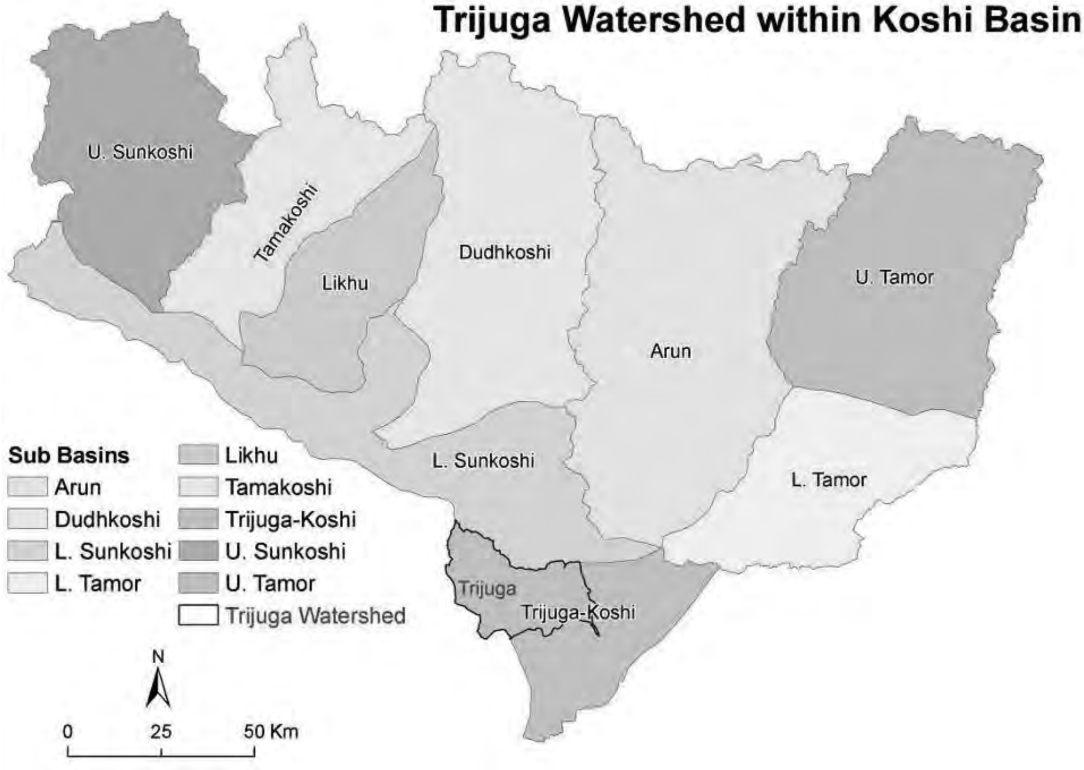

Fig. 4: Location of Trijuga Watershed in Koshi Basin.

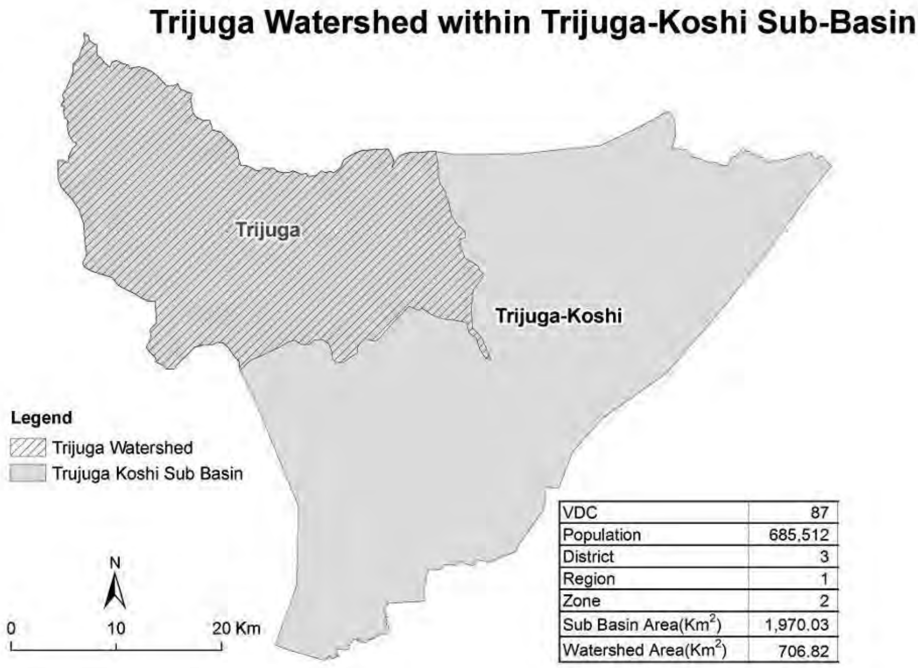

Fig. 5: Location of Trijuga Watershed in Trijuga-Koshi Sub-Basin.

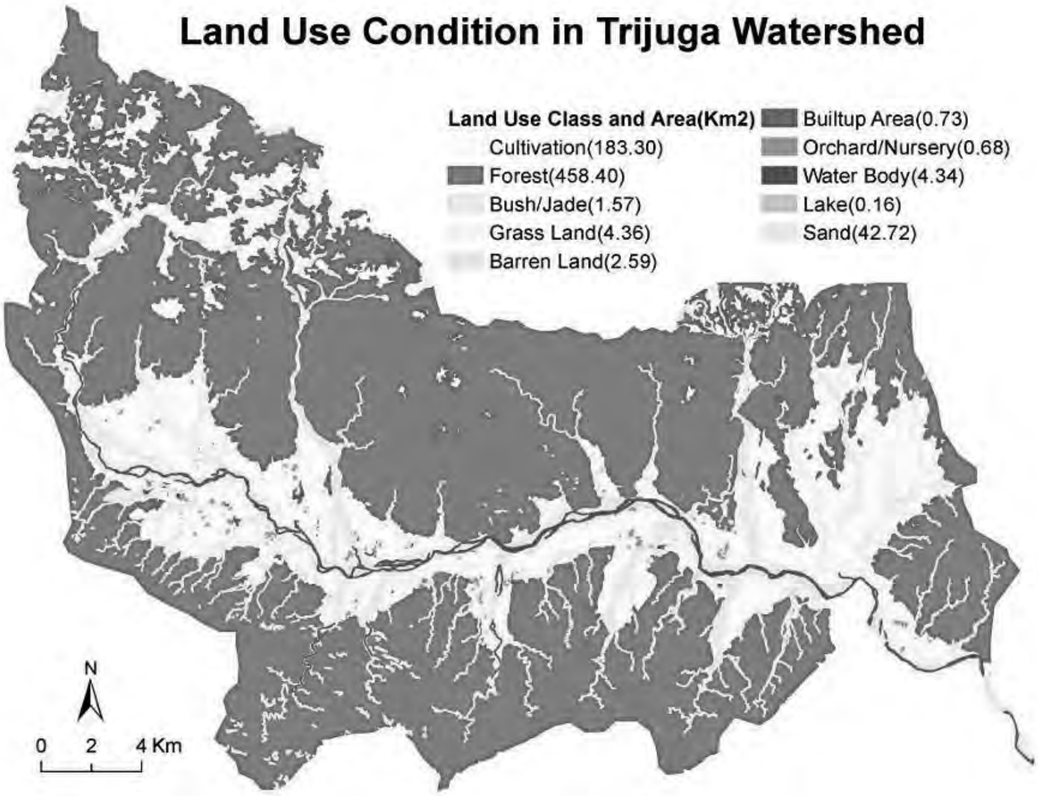

Fig. 6: Land use/ Land cover map of the Trijuga River watershed.

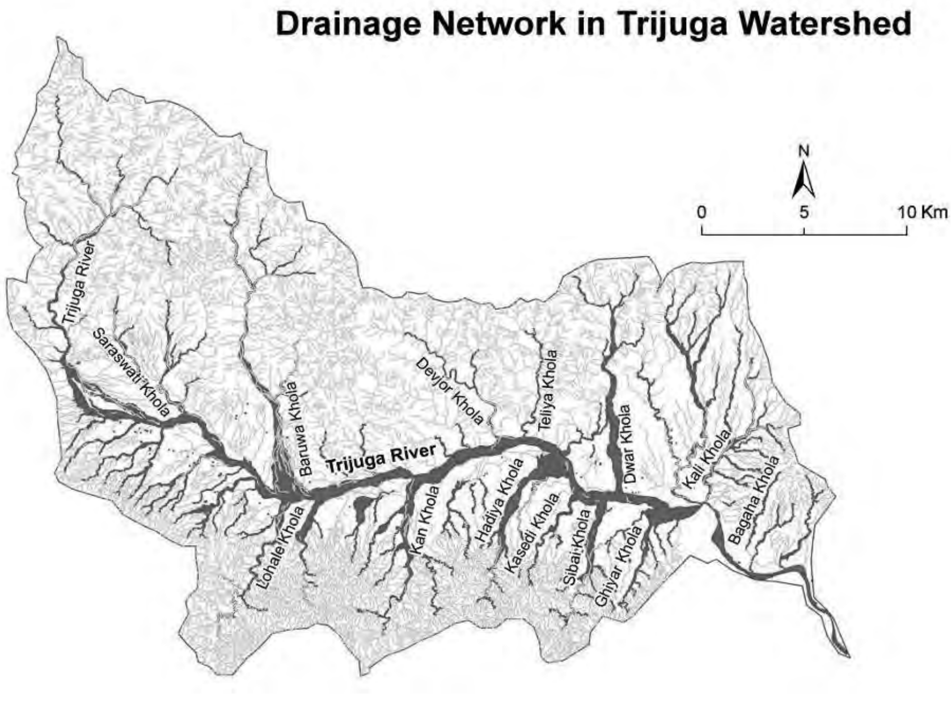

Fig. 7: The drainage network within the watershed.

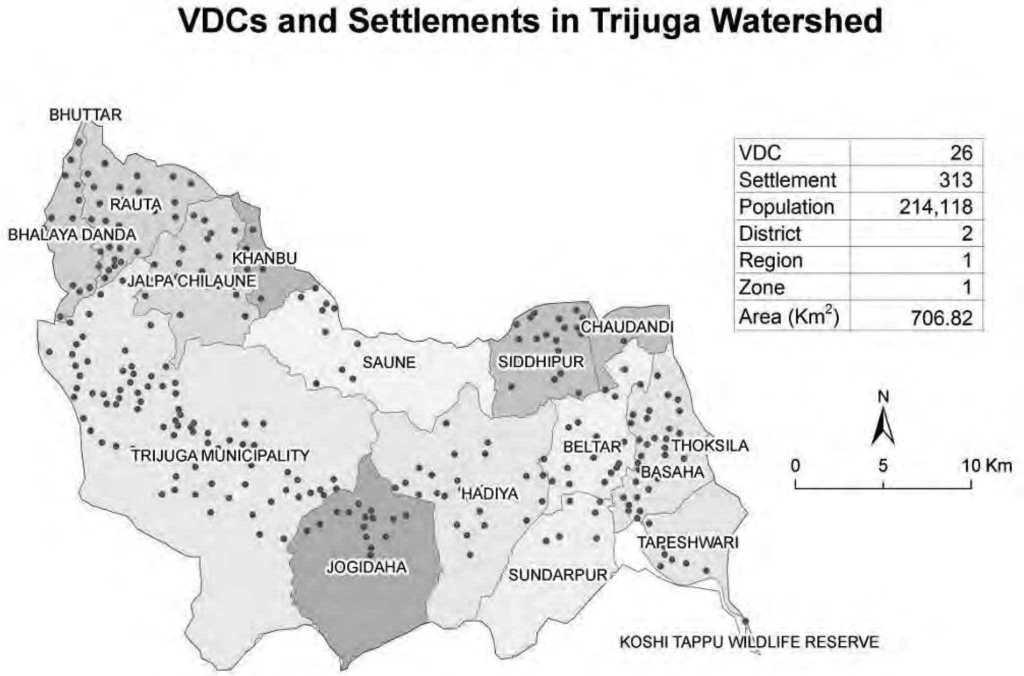

Fig. 8: VDCs and Settlements within the Trijuga Watershed.

DATA AVAILABILITY

A huge amount of data is required for the preparation of watershed atlas of the country. The data availability highly restricts the data to be incorporated in the Atlas. However, the minimum data like population, watershed area, road network, administrative boundaries, major landslides must be included. The other data, related to physical component of watershed like areas of mass wasting, updated information on settlement, forest area change etc. can be extracted from the satellite imageries. The map production can be done interactively in GIS environment.

CONCLUSION

The strategy for watershed management need to focus on all the means that will reduce pressure on the environment, including those that improve productivity, reduce fuel wood demand, and improve fodder, food supplies, and other environmental resources. This can be achieved through the basin management plans for all major river basins of the country. This task demands database at basin, sub-basin and watershed scale. There is a need to systematic delineation, collection and storage of basin/sub basin/ watershed data on a convenient working scale. The statistics and the maps (hard copy and GIS database) can be of immense importance to watershed management planning including watershed prioritization. Watershed atlas of the country can be helpful to watershed management agency as well as other natural resources management institutions and local level government and non government agencies.

Himalayan wetlands: A geological perspective for their evolution and conservation

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ABSTRACT

Water bodies are called by several terms like lake, pound, swamp, and marshy land. These water bodies are also known collectively as wetlands. Conservation of wetlands is important not only for peoples' livelihood management but also for regional ecological balances. But the conservation practices of wetlands, at several instances, do not include the geological components of the sites at which wetlands are originated. An attempt is made in this paper to provide an account of the origin of the Himalayan wetlands based on literatures reviews, interpretation of geological information, and site characteristics of some lakes. Results indicate that the geological processes such as glacial, fluvial, tectonic, and mass movement processes are responsible in resulting wetlands in the Himalayan region. It is therefore recommended to consider geological characteristics of wetlands and their surroundings while designing and implementing suitable countermeasures against their degrading state of environment.

INTRODUCTION

Water bodies are called by several names like lakes, pounds, swamps, and marshy lands. These water bodies are also known collectively as wetland. According to National Wetland Policy (NWP, 2003), "wetlands denote perennial water bodies that originate from underground sources of water or rains. It means swampy areas with flowing or stagnant fresh or salt water that are natural or man-made, or permanent or temporary are wetlands. Wetlands also mean marshy lands, riverine floodplains, lakes, ponds, water storage areas and agricultural lands." Water bodies in Nepal comprise of over 6000 rivers, 3252 glaciers, 2323 glacial lakes, 23000 pounds, 163 wetlands, and over 2700 oxbow lakes in the Terai and over 480 tectonic lakes in the middle mountains (Pokharel and Nakamura, 2011). Besides natural wetlands, constructed or man-made wetlands are also in existence. The latter types are developed to fulfill certain human needs and thus, their ecological influence is limited. On the other hand, the former are resulted due to natural causes, particularly in conjunction with geological processes. Thus, they serve as an important component of local and regional ecosystem depending upon their size and geographical distribution. These wetlands are not only valuable natural resources but are also natural habitat of many endangered flora and fauna. Himalayan lakes have global significances: they have potential for trans-Himalayan conservation, they sustain higher biodiversity hotspots, they support socio-economy of large section of people, and they form foundation for religious and cultural development (Pokharel and Nakamura, 2011). But, in recent decades, rivers and ponds are significantly encroached threatening not only their natural state of environment but also their territories (Fig. 1). It has affected, among others, biodiversity, groundwater recharge and discharge processes, water pollution, spiritual and religious significance, wildlife habitat lost, and most importantly livelihood of local people. Discussing major obstacles for managing mountain wetlands as inaccessibility, extreme climatic condition, and lack of related data Bhandari (2007) has also identified rapid sedimentation, vulnerable to flood hazard, overuse of resources, and pollution as the threats to Himalayan wetlands. Mool et al. (2001) has prepared an inventory of glacial lakes where as the National Lake Conservation Development Committee (NLCDC) has listed name of lakes situated below 3000m of altitude. But what is lacking in these inventories is that there has not been any mention of the geological contribution in resulting lakes in Nepal.

An account of the glacial lake failures in the Hindu Kush Himalayan region is provided by Osti et al. (2010). An example of 3 m lowering of water level of Tsho Rolpa Lake by constructing structural measures (test siphon and channel) to mitigate possible Glacial Lake Outburst Flood (GLOF) can be found in DHM (1998). Besides, some local level initiatives are also in place to conserve the wetlands as a means of conserving, among others, natural ecosystem of the area. But it seems that the geological processes, by which the wetlands were originated, are not being taken into consideration in the conservation plan. Such tendency of neglecting the main causes of wetland evolution in the conservation plan will not attain satisfactory result.

The objective of this paper is to provide an account of the geological processes responsible for the evolution of wetlands in the Himalayan region of Nepal. Besides, it also outlines the possible countermeasures to conserve the Himalayan wetlands giving due consideration to local and regional geological setting.

MATERIALS AND METHODOLOGY

Literatures review, interpretation of geological information, and site characteristics of some lakes form the methodology to achieve the objectives mentioned above. The following contents highlight the relevant information used in this paper.

Fig. 1: Taudaha in Kathmandu. The lake is gradually losing its glory due to anthropogenic encroachment.

Peoples' livelihood and wetlands

About 2, 449, 823 people (about 10.79 percent of the total population of Nepal), residing at several parts of the country, are dependent on wetlands for their livelihood (Table 1). About 8,19,277 hectors of land surface is covered by various types of wetlands (Table 2), which is about 6 percent of the total land of Nepal. Not confined within a certain physiographical region or geological unit, the wetlands are distributed almost randomly all along the country.

Table 1: Ethnic groups dependent on wetlands in Nepal (CBS, 2001)

Ethnic Group	Places	Population	% of Nepal's total population 22, 736, 934
Tharu	All over the Terai	1, 533, 879	6.75
Mushar	East to Narayani. Concentrated in Nawalparasi	172, 434	0.76
Dusadh/Paswan/Pasi	Parsa	158, 525	0.70
Kewat	Nawalparasi	136, 953	0.60
Mallah	Concentrated near Gandak barrage in western development region	115, 986	0.51
Kumal	Chitawan	99, 389	0.44
Majhi	Inner Terai	71, 614	0.32
Danuwar	Jhapa, Morang, Siraha, Sindhuli	53, 229	0.23
Dhangar/ Jhagar	Morang, Sunsari, Sarlahi	41, 764	0.18
Bantar / Sardar	Sunsari and Saptari	35, 839	0.16
Darai	Nawalparasi and Chitawan	14, 859	0.07
Bote	Nawalparasi and Chitawan	7, 969	0.04
Barhamu /Baramu	Gorkha	7, 383	0.03
Total		**2, 449, 823**	**10.79**

Table 2: Estimated land coverage by different wetlands in Nepal (DOFD, 2012)

S. No.	Wetland types	Estimated coverage	
		Area (ha.)	**Percent (%)**
1	Rivers	3,95,000	48.2
2	Lakes	5,000	0.6
3	Reservoirs	1,500	0.2
4	Ponds	7,277	0.9
5	Marginal swamps	12,500	1.5
6	Irrigated paddy fields	3,98,000	48.6
Total		**8,19,277**	**100**

Geology and wetlands

It is believed that the origin of the Himalaya started about 55 Million years ago when the northward moving Indian plate collided with the southern edge of Asia (Tibet) closing the intervening Tethys Sea that was lying between them (Searle et al., 1987). During the collision the Indian plate subducted beneath the Tibetan plate. But the Indian plate could not be sunk further down as the materials lying below the plates were of higher density in nature. Consequently, the tectonic forces caused the plates to be folded, faulted, jointed and uplifted initiating mountain building processes in the region. The Himalayan mountain range is the result of the continent-continent collision. Since the Indian plate is still moving northward against the Tibetan plate, mountain building process is still going on. The tectonic framework of about 800 km long Nepalese Himalayan mountain belt is generally divided into five major contrasting tectonic zones having east-west extension (Gansser, 1964). The tectonic zones are separated by major faults which are responsible in controlling the basic framework of the Himalaya. These master faults, which extend all along the Himalayan range, are known as the Main Central Thrust (MCT), the Main Boundary Thrust (MBT) and the Main Frontal Thrust (MFT) from north to south, respectively. The thrusts get younger in age from north to south: the MCT being the oldest and the MFT the youngest. During the movement along the MCT, a 25-30 km thick pile of overlying rocks moved southward for over 200 km (Parrish and Hodges, 1996) overriding a different set of rocks in the south. The MBT and MFT also moved in a similar manner at different times. At present, significant movement occurs only along the MFT which today forms the most active structure of the Himalaya (Harrison et al, 1998).

As shown in the geological map of Nepal (Fig. 2), each of the tectonic zones is characterized by their own distinct lithology, tectonics, structure and geological history, which are somehow, collectively or independently, related to the

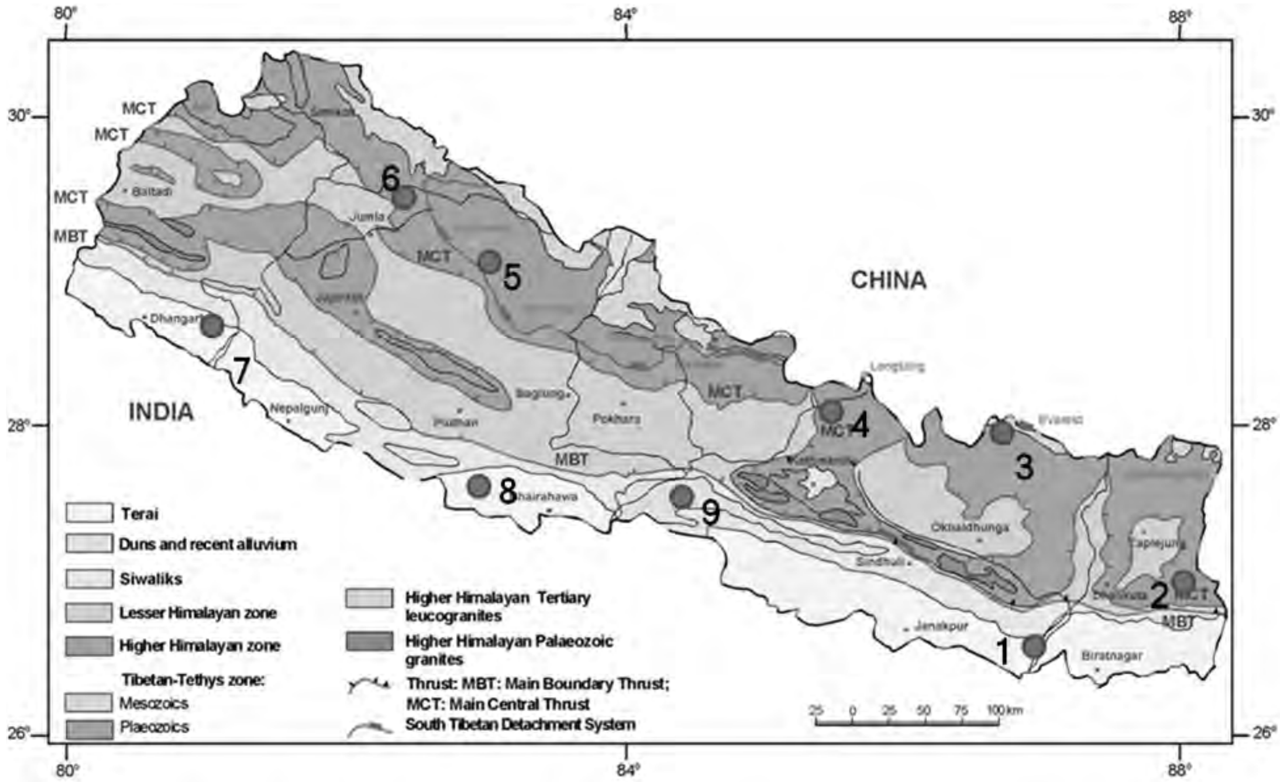

Fig. 2: Geological Map of Nepal (Upreti and Le Fort, 1999). Approximate location of Ramsar wetland sites in Nepal is also indicated (see also Table 3).

formation of wetlands in the Himalayas. For example, the nine Ramsar wetland sites are situated at different tectonic zones, and their dimensions also vary considerably. Their origin is also not by the same natural process but due to various different causes including human activities (Table 3), which will be discussed in detail in latter sections.

Table 3: Ramsar sites (wetlands) in Nepal

S. No.	Ramsar site	Tectonic zone	Latitude	Longitude	Area (km^2)	Elevation (m, amsl)
1	Koshi Tappu Wildlife Reserve*	Terai	26.05	86.98	175	90
2	Mai Pokhari	Higher Himalaya	27.05	87.9	0.9	2100
3	Gokyo Lake	Higher Himalaya	27.98	86.67	77.7	5000
4	Gosaikunda	Higher Himalaya	28.08	85.42	10.3	4700
5	Shey-Phoksundo	Tibetan-Tethys	9.2	82.95	4.94	3610
6	Rara Lake	Higher Himalaya	29.5	82.08	15.83	2990
7	Ghodaghodi Lake	Terai	28.68	80.95	25.63	205
8	Jagdishpur Reservoir**	Terai	27.58	83.08	2.25	195
9	Bees Hazar Tal**	Siwaliks (Dun Valley)	27.58	84.43	32	285

*Flood plains of the Sapta Koshi River **Man-made wetlands

RESULTS

Evolution of the Himalayan wetlands

In geology, lakes' sediments (lacustrine deposits) are considered to be important materials to study the past records of depositional environment including climatic condition. As an attempt to reflect geomorphic importance, the lake is grouped and described in terms of its shape (length x breadth x depth) which could be of circular, elliptical, rectangular, half moon, triangular and irregular shapes. On the basis of their origin, lakes could be classified as structural basin (tectonic), mass movement basin, glacier basin, fluviatile basin (damming of river valley), volcanic basin, meteorite basin (meteorite impacts), and shore line basin (Richard, 1983). The latter three types of lakes are not found in Nepal. Although a detail exploration is still lacking, it seems that the other remaining varieties of lakes are existed in Nepal. As the geological setting of the country varies considerably, particularly in the north south direction, geological processes responsible in originating lakes in Nepal also differs accordingly as described briefly below.

Fluvial processes: This process is more convincing in Terai region. Lying on the southern most part of Nepal, the Terai zone depicts three distinct geomorphological units namely, from south to north, Southern Terai, Middle Terai and Bhaber Zone. The grain size of the sediments in the Terai Zone decreases from north to south having coarser sediments like gravel, cobbles and boulders in the Bhabar Zone and finer sediments such as silt and clay in the Southern Terai. In the Middle Terai, the sediments are of intermediate nature consisting of gravel and sand intermixed with silts and clays.

The Bhabar Zone forms the major recharge area for the groundwater in Terai. Following the surface elevation, the groundwater also flows from north to south. As soon as the groundwater arrives at the Middle Terai, the rate of groundwater flow decreases owing to the comparatively finer sediment size (lower permeability comparing to the situation of Bhabar Zone). It causes the groundwater to flow further south with rise in water table across the Middle Terai. Once the groundwater enters into the Southern Terai, the rate of groundwater flow further decreases because of the lower permeability of the sediments (fine sand, silt and clay). Consequently, water table rises further up and at some low lying areas it just emerges on the earth surface resulting natural wetlands (marshy land, swampy or water logged) in the southern part of the Middle Terai (Bhattarai and Rao, 1989). Many of the wetlands found in Terai are formed by this process.

Several rivers flowing across the Terai often meander in an attempt to maintain equilibrium under the existing stress condition. Consequently, rivers start eroding more at some locations and initiate depositing in other places. This process sometimes compels rivers to shift their channel. While doing so, they left behind oxbow lakes (abandoned river channels) which, at many instances, are preserved as wetlands. Besides, once the rivers, with high sediment loads, enter the almost flat ground of Terai plain, they develop an alluvial fan. Within the alluvial fan, the depth and velocity of a river reduces significantly crating networks of several small channels, separated by small alluvium deposits. This process results the braided river channel where several isolated and or inter-connected water bodies may exit. The Koshi Tappu Wildlife Reserve is an example of wetland developed by the braided river channel.

Mass movement process: Nepal is vulnerable for various types of mass movement hazards such as landslide and debris flows due to steep topography, on-going mountain building processes, highly fractured rocks, diverse climate and intense precipitation. Strong earthquake shocks also alter the local elevation and also trigger landslides. Landslides in mountain

slopes sometimes block rivers or streams creating an artificial dam across the rivers. The artificial dam is breached in a few hours in case of big rivers. But in case of small rivers or seasonal rivers, the damming by landslide may create a lake permanently, particularly if the river discharge is very low and the volume of the landslide materials is considerably high. Sometimes a major river deposits huge amount of sediments at the confluence of its minor tributaries. This event dams the natural flow of the tributary creating a lake behind the dam. Several lakes have been resulted with this process in mountains of Nepal.

Limestone is slightly soluble in water, particularly when it contains carbonic acid. As the water flows through the cracks formed in limestone, channels are slowly widened until cave and caverns are created. Later, these cave and caverns are collapsed forming larger depressions called sinkholes. In some instances, the sinkholes are filled up with water forming lakes. As there are many limestone terrains in Himalayan region, there remains a possibility that the sinkholes could have been preserved as wetlands.

Tectonic process: Fault is a geological structure which could also contribute for wetlands formation. Once the faulting process initiates, earth surface (rock or soil) lying on one side of the fault gradually up rises. Although the process is very slow, it can block river channels or can force a river to change its channel after continuously acting for thousands of years. This sort of process was responsible to create the paleo Kathmandu Lake (ancient wetland) after blocking the Bagmati River by upliftment of the Chandragiri Mountain by a fault. Latter, the fault became passive (inactive) and the Bagmati River eroded the upraised part of its channel draining out the paleo Kathmandu Lake. Thus, a beautiful wetland was originated and latter vanished by tectonic causes (mainly faulting). It is likely that similar conditions must have been existed to give rise wetlands or to vanish them in other part of the Himalayan region including in Dun valleys, where a thrust fault, known as Central Churia Thrust (CCT), passes longitudinally throughout the valleys.

Glacial process: Glaciers are moving mass of ice. They are common in the higher Himalayan region of Nepal. The grinding weight and pressure of advancing and retreating ice sheets carved many depressions on the Earth's surface, where melting ice then be collected to form lakes. Similarly, when ice sheets move over flat rock surface with several inter-connected weathered joints, then the rock blocks could be fragmented and transported away leaving behind a basin called "glacial scour lakes". Likewise, when a large chunk of glacial ice is left behind during glacier receding, the ice itself could create a depression and melt to fill it, creating a "kettle lake" (Fig. 3). Kettle lakes are irregularly shaped in the manner of the original ice blocks that produced them (Wetzel, 2001). Moraine lakes are formed when glacial melt is collected in depressions created within a glacial till. Besides, if a glacier retreats the moraine deposits may be left behind, both at the terminus of the glaciers and along the sides. The terminal moraines act as a natural dam which may block the outwash flow or the snow melt water coming from the higher elevation. This process also results beautiful glacier lakes. There are several lakes resulted due to glacial process in the Higher Himalayan Zone and Tibetan -Tethys Zone. The Ramsar sites namely, Gokyo Lake and Shey-Phoksundo Lakes were evolved due to the glacial processes.

Fig. 3: A small kettle lake situated on the way to Gokyo in Solukhumbhu district.

CONSERVATION OF HIMALAYAN WETLANDS

Geological roles in conservation: As already outlined above, the Himalayan region has different geological settings which have caused not only heterogeneous climatic condition but also variation in geological structures and rock / soil types (Fig. 4). It means wetlands existed in Terai and in hilly region cannot be conserved with similar approaches because their origin may not be from the same geological processes. It implies therefore that the wetland conservation activities may differ from place to place depending particularly on the characteristics of geological zones or geomorphic features in which wetlands are existed.

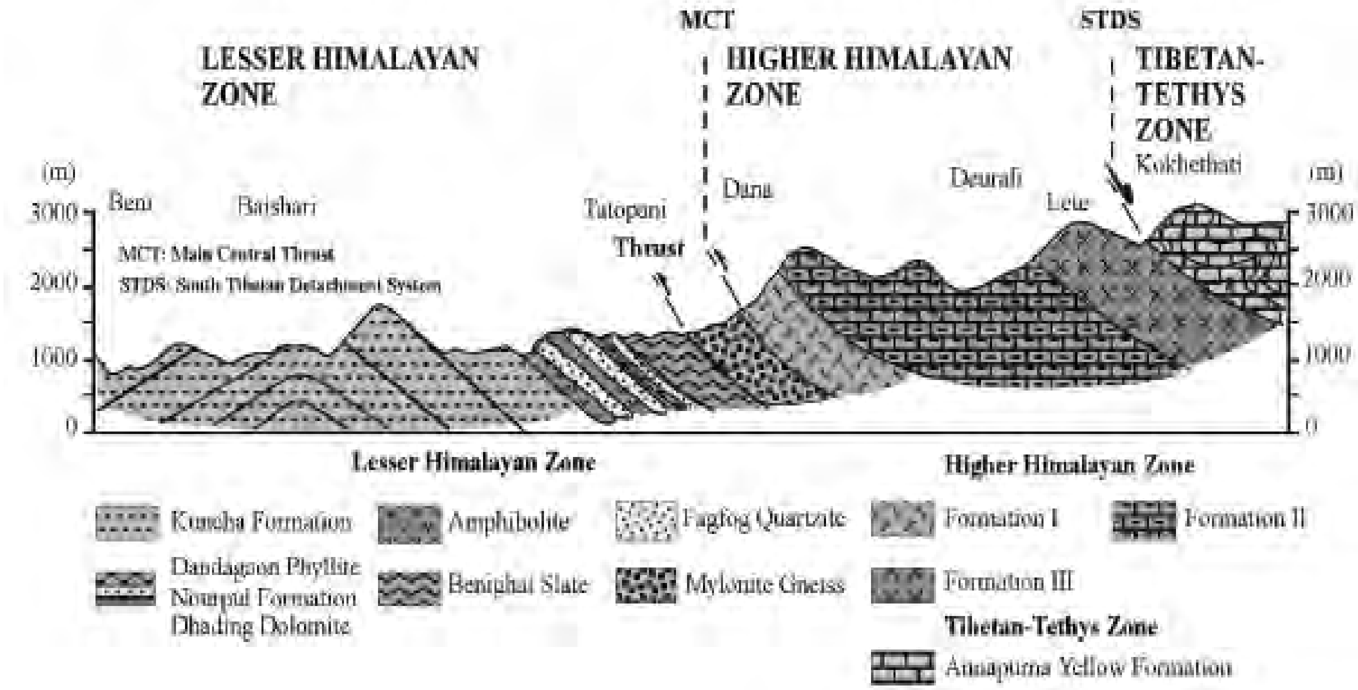

Fig. 4: Geological cross section (north-south) between Beni (south) and Kokhethati (north), almost along the Kaligandaki River, showing major faults and folds structures in the Lesser Himalaya, Higher Himalaya, and Tibetan-Tethys Zones (Upreti and Yoshida, 2005).

Conservation of wetlands in Terai region: Besides controlling soil erosion along the inlets and around the wetlands, it is also equally important to investigate geological structures in and around the wetlands. Presence of a fault might help to interpret whether the water is coming /going along the fault. Besides, extraction of groundwater should not be allowed for large scale irrigation purposes in the area. Aquifer mapping should be made and the related recharge area should be identified and protected in order to maintain natural groundwater flow to the wetlands and also to protect the wetlands from pollution. Wetlands should also be protected from floods as the Terai region is vulnerable to flooding. Preparation of landslide and flood hazard maps would help to plan, design and implement wetland conservation activities successfully.

Conservation of wetlands in mountainous region: In addition to soil erosion control measures, landslide inventory and hazard map of the area should be prepared. Such map helps to identify whether the wetland is endangered by landslide related processes. A detailed engineering geological map of the wetland area should be prepared to reveal geological structures, rock types and their weathering condition, extent of gully erosion, soil types and their thickness. This information is needed to understand the responsible geological processes threatening the existence of the wetlands. Besides, such information also helps in designing suitable countermeasures against any unwanted changes being taking place in and around the wetlands. The anthropogenic activities like road, hydropower, and irrigation canal construction may initiate and accelerate mass movement processes which have potential to adversely affect the wetlands of the area. Therefore, physical infrastructures development projects should have a component of conserving wetlands, based on the findings of geological investigation, during their implementation.

As already mentioned above, there are several wetlands resulted due to glacial activities in the northern part of the country. According to Mool et al. (2001), several of them are rapidly growing in size posing a threat for resulting glacier lake outburst floods (GLOFs). The rapid melting of glaciers, which increases water volume in glacial lakes, is attributed to the impact of climate change (IPCC, 2007). Past GLOFs events in the Himalayan region were also somehow linked with climate change accordingly. But a case of GLOF event resulted due

to the occurrence of a big landslide along an active fault on a side of the Tam Pokhari glacial lake has also been highlighted (Osti et al., 2011). This indicates that a geological investigation in and around the glacial lakes is utmost important to design and implement suitable countermeasures against lake dams' failure. Besides, it is also equally important to investigate for the possibility of falling snow avalanche on the lakes, which may also cause lakes' wall failure.

Conservation of wetlands in rain shadow zone (Tibetan -Tethys Zone): It may be important to mention that the snow line is gradually shifting to high elevation due to climate changes. Consequently many lakes, formed by glaciers in the past, are isolated from the main glacier body now. Such lakes receive no water from snow melt. They are survived by rainwater and to some extent groundwater. Such lakes, found in rain shadow zones, are likely to vanish gradually because the rate of evaporation seems to be increasing year by year but the amount of precipitation is almost constant or decreasing in some cases. At the same time, sediments coming into the lake with flood water, though less frequent, is also increasing. Therefore, construction of check dams across the lakes' inlet is vital to control sedimentation in the lake. Similarly, some sort of rain water harvesting or groundwater discharging techniques (based on hydro-geological investigation) should be adopted to conserve wetlands in the rain shadow zone of the Himalayan region.

CONCLUSIONS

The Himalayan region is subdivided into different geologic (tectonic) zones each of which are characterized with contrasting geologic history and different rock types. Since rock types, soil types, geological structures and geological processes have a link with the formation and natural life span of wetlands, conservation plan should include geological investigation of the area. It is utmost important to understand the processes, by which the wetlands were originated, to have their sustainable conservation. Engineering geological map, landslide inventory and hazard map and flood hazard map should be prepared to understand the origin, and likely unwanted changes being taken places in and around the wetlands. Such information is equally important to design and implement suitable countermeasures to conserve the wetlands.

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Mineral Identification using X-ray diffraction method and its application

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ABSTRACT

X-ray diffraction method helps to determine the types and quantity of the minerals within the rocks and sediments. Powder diffractometry is the method generally used to study sedimentary materials. It is very important tool for those rocks where petrographic methods are of limited utility. XRD method is superior method for clay and non-clay mineral identification. It indicates nothing about textural relationships within the rocks. The amounts and their variation of minerals in different locations of the same basin or different basin were estimated by using the X-ray diffraction (XRD) method, in order to estimate the source of the basin sediments and to interpret paleoenvironmental and paleoclimatic condition of the depositional basin. Identification and quantity of non-clay minerals are mainly used for source region of the depositional basin. On the other hand, identification and estimation of the clay minerals are mainly focused on the paleoenvironmental and paleoclimatic condition of the depositional basin.

INTRODUCTION

X-ray diffraction (XRD) is an important tool in determining the mineral of the sediments and sedimentary rocks. Both the mineral species and semi-quantitative determination of mineral substance easily determine by this method can also be made. A monochromatic beam of X-ray passing through a mineral grain is scattered by the atoms that compose the mineral. At specific angle of incident, the scattered X-rays are in phase producing an intensified secondary beam. This phenomenon is known as diffraction. W.L. Bragg and L.H. Bragg (1913) noted that diffraction could be pictured as a reflection of the X-ray beams by planes of atoms. Hence, the XRD is applicable for measure the average spacing's between layers or rows of atoms, determine the orientation of a single crystal or grain, find the crystal structure of an unknown material, This paper could provide the modern baseline for more accurately interpretating ancient clastic deposits, their possible origin and composition of minerals of the basin-fill sediments. On the basis of the variation of minerals within the sediments and geology of the Valley, it will make tool to determine the source of the recent and ancient sediments and then use mineralogical data for estimation of the provenances of the basin-fill sediments, paleoenvironmental and paleoclimatic condition of the studied area.

EXPERIMENTAL DETAIL OF NONCLAY MINERALS

The sample was dried for 24 hours at 50° C in air bath and then weighed. The dry samples were divided into two fractions, clay (less than 2μm) and non-clay part (greater than 2μm) by the gravity sedimentation methods. Non-clay part of the samples was dried for 24 hour at 50° C on the hot plate and then weighed. This sample was then made powder in the agate mortar. Finally, 10 wt % of zincite (ZnO) was added as an internal standard into this powder samples. Zincite is suitable for the internal standard for XRD quantitative analysis because it provides stronger and more conveniently located reflection (Srodon et al 2001).

XRD experiment method

XRD measurement were done by the Rigaku X-ray Diffractometer RINT 2100V, using CuKα radiation monochromatized by a curve graphite crystal in a step of 0.02°with a step-counting time of 2 second. The profile-fitting obtained XRD patterns was performed with an Apple Power Macintosh computer and a scientific graphical analysis program XRD MacDiff (Petschik 2000). The result of an individual mineral obtained from the profile-fitting method was used for quantitative analysis. (Kuwahara 2001).

Quantitative analysis of non-clay minerals

Relative amounts of minerals within the sediments were determined by calibration curve obtained from integrated intensity ratio of the standard mineral to internal standard zincite (Fig.1). The standard mineral quartz, K-feldspar and mica were collected from sand sample. For others, plagioclase, chlorite and calcite were collected from other locations, with similar chemical composition as the basement rocks of the

study area.

Mixture of 10 wt % internal standard zincite and a known percentage of each standard mineral was analyzed by XRD under the same condition describe above. The integrated intensity of each mineral was estimated from XRD data (Fig.3) using a program XRD MacDiff. (Petschik 2000). From the calibration curve (Fig.1) we obtained the following equations for individual minerals are as follows:

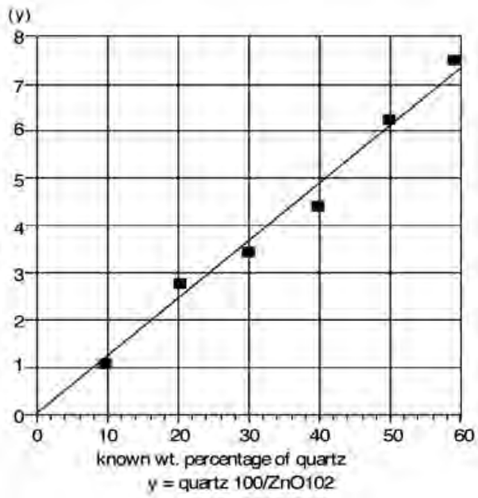

Fig.1: Calibration curve for quantitative analysis of minerals (quartz).

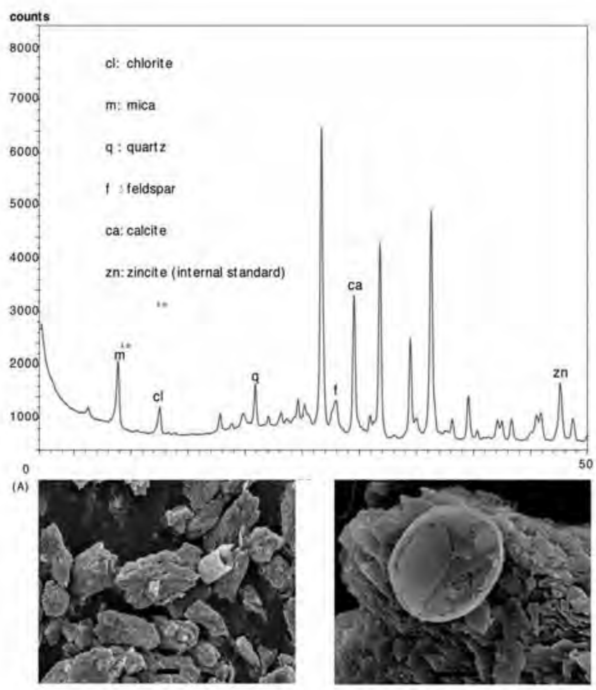

Fig.2: Representative XRD pattern after peak fitting of sample including all minerals and their SEM image showing mainly calcite overgrowth and diatom valve.

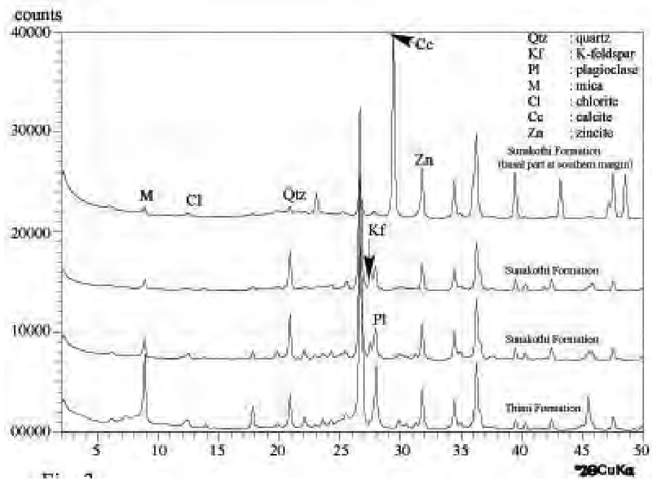

Fig.3: XRD Pattern of the non-clay mineral from XRD raw data to Peak-fitting data (After Paudel et.al.2004 and Paudel 2014).

Quartz (Y) = 8.173615E+0 y+0.000000E+0 (y=quartz/zincite)

K-feldspar (Y) = 0.05177 $(y)^3$-1.26 $(y)^2$ +1.299 10 y (y = K-feldspar/zincite)

Plagioclase (Y) = 2.625 y (y = plagioclase/zincite)

Mica (Y) = Power (y, 0.707) exp (1.509) (y =mica/zincite)

Chlorite (Y) = 3.612 y (y =chlorite/zincite)

Calcite (Y) = 4.349 y (y = calcite/zincite)

CLAY MINERALS AND CLAY SIZE FRACTION ANALYSIS

Typically, clay mineral analysis involves the separation of a clay sized fraction (usually < 2 micron) from the given sample. Most of the non-clay minerals, which are usually present in small amount in association with clay minerals, are removed in the initial chemical pretreatment. Calcite and quartz are two major minerals which are not completely removed from samples. Each clay fraction of the sample was collected by the Millipore® filter (0.45 µm pore, 47 mm diameter) transfer method to provide an optimal orientation (Moore and Reynolds, 1989). Both air-dried (AD) and ethylene glycol solvated (EG) preparations were done for each sample. The potassium-saturated treatment (KS) was also performed for selected samples. Once obtained the clay fraction is prepared by collecting it on a filter and transferring the layer of clay to a glass slide substrate. This so called 'filter peel' method enhances the preferred orientation of the platy clay particles which helps to obtain a good diffraction signal from the diagnostic basal planes of the clay minerals. It is also the best

way to make a homogenous sample, essential is quantitative results are required. These oriented samples are run on the diffractometer (air-dried) and then run again following various treatments such as solvation with ethylene glycol, and heating

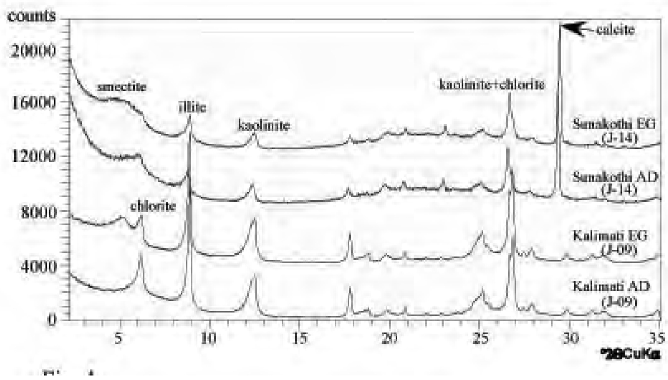

Fig.4: XRD Pattern of the clay mineral from XRD raw data to Peak-fitting data (After Paudel 2014).

to specified temperatures for specified times. Other treatments may be appropriate for the identification of some clay minerals. All XRD measurements were done by the Rigaku X-ray Diffractometer RINT 2100V, using CuKα radiation monochromatized by a curve graphite crystal in a step of 0.02°with a step-counting time 4 seconds for clay samples. The XRD raw data of clay fraction were treated by a program Mac Diff (Petschick, 2000) on an Apple Macintosh computer, in order to determine the integrated intensity (peak area) of XRD peak corresponding to each mineral Peak positions (Fig.4), shapes and intensities and changes in these between treatments are diagnostic for the identification of different clay minerals. Following identification, quantitative analysis may be made by an intensity ratio method whereby the integrated intensity (peak area) of selected clay mineral peaks is related to their weight fraction in the mixture by means of a predetermined constant of proportionality termed mineral intensity factors (MIF) (Moore and Reynolds,1989).

DISCUSSION AND CONCLUSION

Some common and clay minerals are very useful for an interpretation of environmental and climatic condition of the given region. Among these minerals clay minerals are important for environmental indicators. Particularly, clay minerals may provide some information on the climate in the source region e.g. kaolinite is produced under warm humid condition, while montmorillonite is produced mainly in arid and temperate climate. Clay minerals composition may provide useful information on the climate and weathering characteristic in the provenance. As for example kaolinite develops in soil of extensive leaching and acidic condition mostly associate with warm humid climate. Illite is produced by decomposition of feldspar and degradation of mica in initial stage of weathering in an alkaline and presence of Ca^{2+}ions. Chlorite is formed by hydrolysis of ferromagnesian minerals under alkaline condition (Millot 1970). Above minerals are important in defining a given environmental and climatic condition. Therefore, clay minerals in the sediments of the given area may have information on climate and/or depositional environments. Here, I suggested variation of phyllosilicate and non-phyllosilicate as the key mineral for the depositional and environmental changes of the Kathmandu Basin (Table 1). The amount of phyllosilicate is high in wet climatic condition in the lacustrine environment. As the amount of precipitation increased, flow of water was raised, the alteration of the primary minerals as well as the deposition of the phyllosilicate in the lake basin became fast, and consequently the amount of phyllosilicate would be expected to increase. Therefore, I used phyllosilicate as indicator of wet climatic condition. Conversely, in dry period, amount of phyllosilicte is low due to weak alteration of the primary minerals as well as transportation and deposition from the source to Lake Basin became slow. In addition, high ratio between non-clay and clay indicates dry period, low amount indicates humid period. When climatic condition became dry in the lake environment, water level in the lake was started to become low and dissolved calcareous matter were precipitated in the lake bottom.

Table 1. Index minerals for paleoclimatic and depositional environments

minerals	climatic conditions		depositional environments	
	dry	wet	lacustrine	fluvial
phyllosilicates	low	high	high	low
feldspar	high	low	low	high
total bulk minerals	low	high	low	high
calcite	high	low	high	no
ratio between non-clay & clay	high	low	low	high

Source of the sediments of any basin is very important parameter for the interpretation and reconstruction of geological and tectonic history. Detailed mineralogical and petrological study of the rock surrounding the basin and

mineralogical study of the basin fill sediments could provide the information about the source of the sediments. It showed that the mineralogical study on the recent sediments and the basement rocks in the depositional basin provides valuable information about provenance of the present and past basin-fill sediments, depositional environments and climate. These mineralogical data are correlated with data from the other proxy like diatoms and pollen in the same core sediments (Fig.2).

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Fundamentals of 3D Geological Modelling and Visualisation

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Abstract

3D geological modelling (geomodelling) means the obtaining subsurface models from which information can be gathered and used, for instance, in mineral potential mapping and geo-hazard assessment. A 3D geomodel helps to create and increase knowledge of geological systems and provides new information either visually or by performing quantitative analyses in the modelled geological objects. Geomodelling process involves development of 3D database, defining model constraints, selecting appropriate model resolution, surface construction and visualisation. The visualisation of 3D model with possible functionality of sectional view dynamically enhances the valuable understanding of geometrical relationship between the different geologic features.

Keywords: 3D, geological modelling, model visualisation.

INTRODUCTION

Geological and/or geoscientific information are inherently three-dimensional in nature, and are the product of geological processes. Despite this, many field geo-scientists (e.g. students, academics and national survey workers) still rely upon standard methodologies for recording observations and disseminating published information that are fundamentally one dimensional (1D) or two dimensional (2D) in character (i.e. rely on traditional paper-based mapping methodologies in which three-dimensional real-world data are simplified and displayed in 2D. These methods have remained largely unchanged since the birth of geology as a scientific discipline two centuries ago (Jones et al. 2009). The innate limitation of the two dimensional nature of paper (in the form of field notebook, printed scientific journal or published map) inevitably requires a compromise in the way that three dimensional (3D) data are depicted. In order to show 3D data that minimised distortion of geospatial relationships, traditional approaches necessarily resorted to using 2D maps and cross sections (i.e. involving a loss of dimension). A useful 3D perspective is often gained by showing schematic block diagrams, though these generally involve a loss of spatial precision, and the 2D sections shown on the faces of the blocks still only show a small proportion of the actual 3D rock volume. Another fundamental limitation inherent to paper-based methods is that individual interpretations must be prepared and drafted for display at a single fixed scale. This has a strong tendency to mask scaling relationships that may exist between structures at different orders of magnitude (Jones et al. 2009). In recent years, widespread utilisation of desktop computers and rapid development of dedicated graphics hardware and software has brought affordable, high-performance real-time 3D graphics capability to standard desktop and portable computers, so that modern geological field-based investigation can benefit from 3D visualisation throughout an entire workflow, from primary digital acquisition of field data through to analysis and interpretation (e.g. Jones et al. 2004, McCaffrey et al. 2005, Clegg et al. 2006). The digitalisation of geological field mapping has helped to overcome the limited dimensionality of traditional methods, and also allows integration of data across a very wide range of scales.

The real 3D reconstruction in geosciences modelling belongs to the research field of visualisation in scientific computing (Zhang et al. 2010). That is to render complicated and abstract concepts in intuitive graphics and images, effectively helping researchers to “see” the large amount of experimental data, numerical computation and scientific calculations vividly and connectively in order to understand the phenomena, discover laws and convey knowledge. Therefore, 3D subsurface models and their visualisation are even essential for stakeholders because they are simply the *users* and *funders* of the maps and geodatabase. If the fundamental geologic information is obtained, then many products can be produced that will satisfy multiple users’ needs. Furthermore, 3D subsurface model is generally not an end (Caumon et al. 2009), but a means of: (1) improving data interpretation through visualisation and confrontation of data with each other and with the model being created; (2) generating a support for numerical simulations of complex phenomena (earthquakes, fluid transport) in which structures play an important role.

MODELLING FUNDAMENTALS

3D geological modelling has become a powerful tool to help understand geological structures and is very widely

discussed in engineering geology, oil exploration, mining and other fields (Sprague and de Kemp 2005, Wang et al. 2009). Initially, 3D geological modelling is mainly used for hydrocarbon exploration and production (Chilès et al. 2004, Perrin et al. 2005). However, there is a true potential and interest to make multiuse of the 3D geological models in other fields than the hydrocarbon industry (Xue et al. 2004). Although specialised software now allows modelling complex and irregular geological bodies in 3D, using geological maps, geologic survey records and structural information. 3D geological modelling and visualisation include 3-dimensional reconstruction and digital geological model, simulation and visualisation of geological processes etc. (Wu 2004, Jing et al. 2010). 3D geological modelling is often performed to represent, and eventually better understand the geometric, topological and physical properties of geological objects. A series of sophisticated three-dimensional modelling technologies have been developed to address the need for a precise definition of subsurface conditions (Turner 1991). Geological modelling requires the extension of GIS methods (Turner 2006) and geologists have always recognised the need to view the world as multidimensional. The technique of 3D geological modelling is effective for representing complex geological objects. Thus, 3D geological modelling is an effective mean to integrate data of different majors, periods, sources and types in a unified environment and build up a multi-source data warehouse (Zhang et al. 2010).

In most application fields, 3D modelling is also a means of obtaining quantitative subsurface models from which information can be gathered. Such a 3D Geological Information System can be used, for instance, in mineral potential mapping (Bonham-Carter 1994) and geo-hazard assessment (Culshaw 2005). 3D structural models can be meshed to solve (geo) physical problems and assess or predict production of natural resources, solve geomechanical problems, better understand mechanisms that trigger earthquakes, estimate petrophysical properties of rocks such as porosity or seismic wave velocity in order to simulate physical processes (Caumon et al. 2009) etc.

Geomodelling data

The typical input data for 3D modelling can be quite diverse and may include field observations (for instance, stratigraphic contacts and orientations, fault planes), interpretive maps and cross-sections, remote sensing pictures, and, for high budget projects, LIDAR outcrop data (Bellian et al. 2005), reflection seismic, and borehole data. Geomodelling data are classified into three types (Wu et al. 2005): direct data, indirect data, or assistant data, depending on the type and the purpose of the information and application.

Direct data, such as borehole data and property data, is original sampling data obtained by direct observation and survey, and is highly accurate. It is utilised directly in the 3D modelling system and is managed and stored with databases in MS Access, Oracle, etc.

Indirect data, being original too, has different precision with different resolutions of graphs, such as boundaries, faults, folds and Digital Elevation Model (DEM) derived from geological maps, topographic maps and structural geology maps, as well as 2D/3D seismic-reflection data, exploring data, etc. This type of data should be stored as files after being digitized. However, this kind of data cannot be used as direct input data for the 3D modelling system.

Assistant data, will be used in the process of 3D modelling as icons like 2D/3D primitives, and texture maps including satellite or aerial imagery, scanned maps, etc.

3D Geological model

A geomodel is an abstract digital representation of a part of the Earth's subsurface which is neither directly accessible nor wholly known. Geomodels are derived by interpolation and interpretation of data observed at points and can represent geological situations in 3D space. Knowledge and geophysical models may, for example, be used as additional constraints. In geomodels, there is the 3D representation of the subsurface objects and structures, such as stratigraphic units and their depositional style, fractures, fault and folds. Thus, 3D Geomodels are a collection of data that describe the geometry, the topology and other information linked to geological structures, such as thematic properties of the objects. Also geomodel should help to create and increase knowledge of geological systems and provides new information either visually or by performing quantitative analyses in the modelled geological objects (Zlatanova et al. 2004).

Error probability in model

Knowing how much data is reliable and interpreted is essential for weighting its contribution to the final model versus that of the other data types and one's interpretation. For instance, geological cross-sections are often considered as hard data in 3D model. The incorrect projection of data onto the section plane is a probable error introduced during the stages of cross-section construction when projection vectors are not properly defined to reproduce the 3D geometry of the structure (Carrera et al. 2009).

Approaches in 3D geomodelling

In order to build accurate 3D geological models based on this information, it is necessary to develop a methodology that takes into account the variety of available data. Such models, of the geometry of geological bodies, should also be easy to edit and update to integrate new data. This kind of model should produce a consistent representation of subsurface geology that may be a support for modelling other subsoil characteristics such as hydrogeologic or geothermic properties of the geological bodies. In principal, two different approaches to setting up a 3D geological modelling can be distinguished (Maxelon 2004):

Explicit modelling directly constructs the object of interest. For instance several cross-sections are digitized (or constructed) and combined manually in three dimensions, one follows an explicit modelling procedure (e.g. Cowan et al.

2003). In a simplified view, explicit modelling can therefore be described as advanced three-dimensional drawing. However, the construction is often supported by algorithms optimising the geometric components, like Bézier tools (e.g. de Kemp 1999) or Discrete Smooth Interpolation (DSI; Mallet 1989).
Implicit modelling does not explicitly define surfaces or other geometric components. Instead, the set of three-dimensional input data is used to calculate a volume function, which provides a general formulation of the three-dimensional geometry of the respective body or surface (e.g. Lajaunie et al. 1997, Cowan et al. 2003).

Process of 3D modelling

3D geomodelling process involves development of 3D database, defining model constraints, selecting appropriate model resolution, surface construction and visualisation. The input from a skilled geologist is essential to build a model; the software is simply a tool to facilitate the model-building process (McInerney et al. 2005). Thus, 3D model building is an iterative interpretative process (a) input - digitize contacts and input orientation data (b) compute the model. If the model contradicts some known data, then the geologist must add those additional observations, in order that they are taken into account. Alternatively the geologist can impose interpretation on the model simply by adding (hypothesised) contact data or orientation data. When the model is re-computed, the geologist can again review the model and can observe how the shape of the model has been adjusted as a consequence of interpretation. The process, then, is one where the geologist can test their hypotheses; a geologist may have alternative ideas about the structure – and so can test these alternatives (McInerney et al. 2005). After the completion of database development, data are imported in the geomodeler to be integrated into the 3D modelling process (although simple 3D surface modelling can be handled within many GIS, they do not allow to build surface or volumes with complex geometry such as geological folded and faulted structures). The methodology can include several steps to process data depending on their type (Fig. 1).

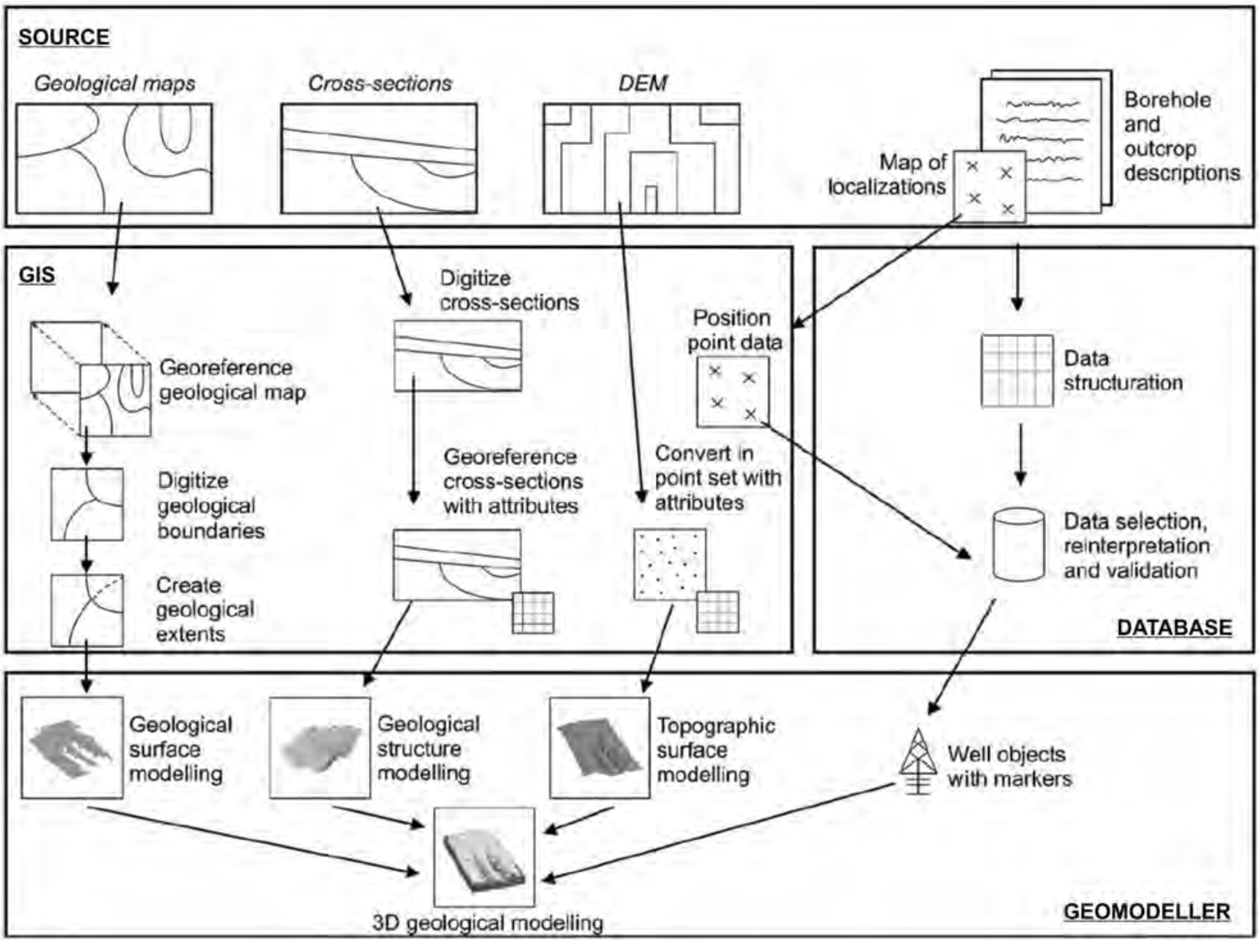

Fig. 1: Basic workflow of 3D geological modelling (Kaufmann and Martin 2009).

MODEL VISUALIZATION

The 3D model visualisation with possible functionality of sectional view dynamically provides valuable understanding of the geometrical relationship between the different geologic features, allowing a re-examination of the tectonic history of the area. However, the "nice" pictures generated with such software should not hide that a model is at best an approximation of geological reality and may simply be wrong, especially away from observations (Caumon 2010) i.e. A 3D surface that is legal from a mathematical perspective does not necessarily represent a valid natural object (Caumon et al. 2009). Therefore, care must be taken whether sound geological rules are implemented while building and computing 3D model in order to have accurate visualisation. The visualisation can be in pre-analytical environment (i.e. displaying various facts without analysis), analysis mode and presentation of final 3D interactive model of virtual reality.

Commonly visualisation represents an aid to interpretation that is built into various workflows for the detailed analysis and processing of data. In an ideal situation, it would be possible to collate all available data for a given project into a single multi-scale geospatial model, and then perform any desired analysis upon the data within one software environment (Jones et al. 2009). However, because data analysis methods tend to be highly specialised for particular purposes, there is a large variety of different kinds of software tools within the general domain of 3D geoscientific analysis (Fig. 2). This often makes it necessary to transfer geospatial data between a numbers of separate software packages within a single analysis workflow which is a major obstacle to being able to adopt an efficient multi-scale geoscientific approach to analysis, since a large overhead involved in transferring data between different formats. While new standards for 3D graphics (e.g. OpenGL) certainly made it easier for software developers to include 3D functionality, the initiatives did little to alleviate data compatibility issues, since visualisation functionality was integrated separately into each vendor's analysis software.

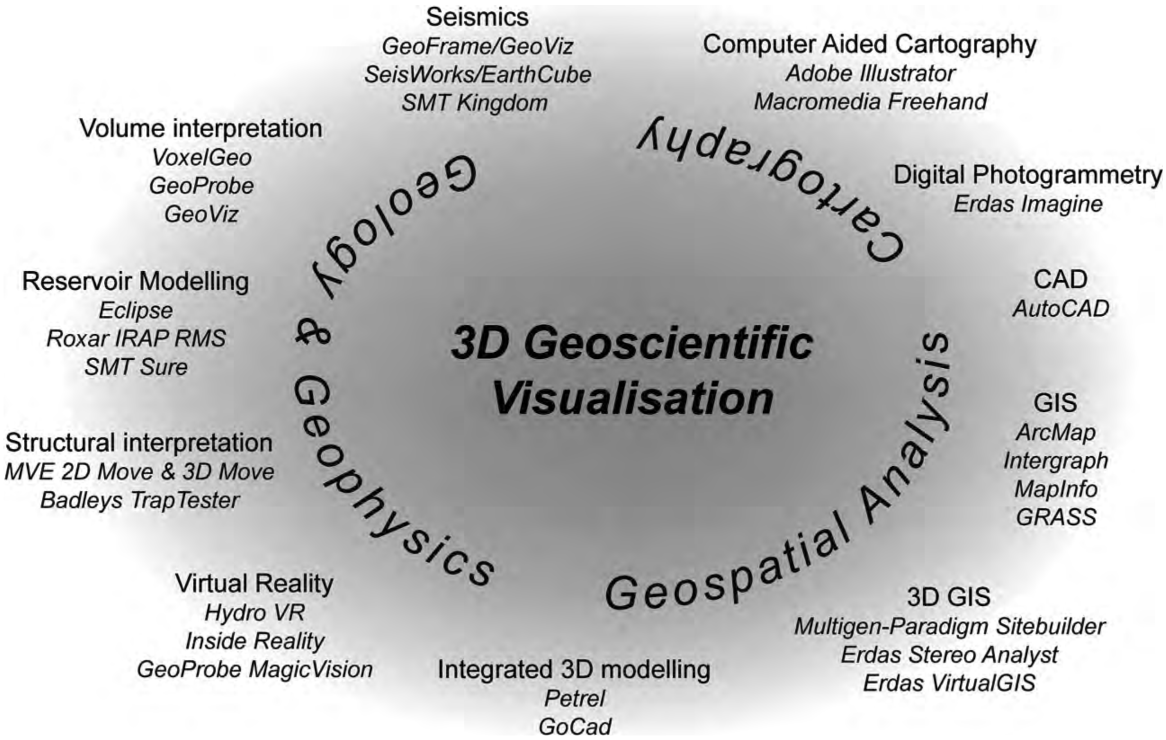

Fig. 2: Application of software in 3D visualisation (Jones et al. 2009).

CONCLUDING REMARKS

3D geological modelling has become a powerful tool to understand geological features by improving data interpretation through visualisation and confrontation of data with each other in computed models. The 3D models have ability to enhance the knowledge of geological phenomena and provides new information either visually or quantitatively which allowing the re-evaluation of models according to geological and engineering judgement.

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बैशाख १२ गतेको विनासकारी भूकम्पः एक विश्लेषण

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सारांश

गत बैशाख १२ गते गएको भूकम्प (म्याग्नेच्यूडः ७.८) सन १८३३ मा गएको विनासकारी भूकम्प (म्याग्नेच्यूडः ७.६) को श्रोतक्षेत्रबाट उत्पन्न भएको अनुमान छ। आधिकारीक तथ्याँक अनुसार यस भूकम्पले हालसम्म सयौं मानिसको ज्यान लिईसकेको छ भने हजारौं घाइते छन, त्यसैगरी कैयौं जनतालाई घरवारविहिन वनाएको छ। सन १९३४ मा गएको महाभूकम्प (म्याग्नेच्यूडः ८.१) पछी आधुनिक नेपालको इतिहासमा यो पहिलो शक्तिशाली भूकम्प हो। हालसम्मको अध्ययन बाट, यस भूकम्पको म्याग्नेच्यूड ठूलो भएता पनि, तुलनात्मक रूपमा अनुमान गरिएभन्दा कम क्षति भएको पाइएको छ। पूरानो प्रबिधि प्रयोग गरेर वनाईएका, काठमाण्डौ उपत्यका लगायत गोरखा र दोलखा जिल्ला विचका अधिकांश, घरहरू ध्वस्त भएतापनि आधुनिक प्रबिधि प्रयोग गरेर वनाइएका, कम तल्ला भएका, घरहरूमा क्षति कम भएको देखिन्छ। काठमाण्डौ उपत्यकामा रहेका, आधुनिक प्रबिधि उपयोग गरि वनाईएका, अधिकांस साना घरहरूमा कम क्षति हुनुमा उक्त भूकम्पको समयमा काठमाण्डौमा low frequency शक्तिशाली तथा high frequency का तरंगहरूको तिव्र क्षय भएको कारण जिम्मेवार देखिन्छ। काठमाण्डौ उपत्यकामा low frequency शक्तिशाली भएको कारणले अल्गा अपार्टमेण्टल भवनहरूमा तुलनात्मक रूपमा बढी क्षति भएको देखिन्छ। उपत्यकाका केही स्थानहरूमा भने (गोंगबु, रामकोट, कौशलटार शोभा भगवती आदि) अन्य स्थानहरूभन्दा बढी क्षति भएको छ जसमा उक्तस्थानको भूवनोट, भूगर्भ र निर्माणक्रममा अपनाइएको कमशल तरिका जिम्मेवार छन।

परिचय

हिमालय श्रृंखला करिव ५ करोड वर्ष पहिले, दक्षिणबाट उत्तरतर्फ गइरहेको भारतिय भूखण्ड तथा उत्तरमा रहेको तिब्बतियन भूखण्डको विचमा भएको टकरावको कारणले उत्पन्नभएको हो। हिमालयको निर्माण तथा यसलाई हालको रूपमा ल्याइपुऱ्याउन अनेकौं शक्तिशाली भूकम्प तथा टकरावपछी विकसीत यस क्षेत्रको जलवायु तथा भूक्षयहरू जिम्मेवार छन। वर्तमानमा पनि भारतिय भूखण्ड उत्तरतर्फ सर्ने क्रममा प्रत्येक वर्ष २ सेन्टिमिटरको दरले हिमालयमा संकुचनको सञ्चय भइरहेको पाइन्छ। यसरी संकुचनको सञ्चय हुनुभनेको भूकम्पको लागि आवश्यक उर्जाको सञ्चय हुनु हो जो भूकम्पको माध्यमवाट क्षय हुने गर्दछ। भारतिय भूखण्ड उत्तरतर्फ सर्नेक्रम एक अनवरत प्रक्रिया भएकोले यस क्षेत्रमा विनासकारी भूकम्पहरू भविष्यमा पनि गइरहने छन।

नेपाल भूकम्प जोखिमको दृष्टिकोणले एक अति उच्च जोखिम क्षेत्रमा पर्छ भनेर अव भनिरहन आवश्यक छैन। गत बैशाख १२ गते गएको शक्तिशाली तथा विनासकारी भूकम्प यसको लागि एक थप प्रमाण भएको छ। लिखित इतिहासमा सन १२५५ देखि यता (सन १९८८ को उदयपुर भूकम्प समेत) काठमाण्डौ उपत्यकामा विभिन्न समयमा १० पटक शक्तिशाली भूकम्पहरूले क्षति पुऱ्याएको पाइएको छ (चित्रकार र पाण्डे, १९८६)। तर यसको तुलनामा नेपालको पश्चिमी भागमा करिव पाँच सय वर्ष यता विनासकारी महाभूकम्प गएको पाइदैन। यसै कारणले, नेपालको पश्चिमी भागमा ठूला भूकम्प जानको लागि यथेष्ट उर्जा जम्मा भइसकेको अवस्थामा उक्त क्षेत्रमा विनासकारी भूकम्प कुनैपनि बेला जानसक्ने सम्भावना व्यक्त गरिएको हो। महाभूकम्प (म्याग्नेच्यूड ८ भन्दा ठूलो) नेपालको गोरखादेखि पश्चिम र भारतको देहरादूनदेखि पूर्वको क्षेत्रमा महाभूकम्प जाने सम्भावना भएतापनि यस क्षेत्रभन्दा पूर्वमा म्याग्नेच्यूड ७ भन्दा ठूलो भूकम्पको लागि आवश्यक शक्ति जम्मा भइसकेको र म्याग्नेच्यूड ८ भन्दा सानो भूकम्प जानसक्ने सम्भावना विद्यमान थियो (सन २००९ मा नेपाल भौगर्भिक समाजको बुलेटिनमा प्रकाशित मेरो लेख हेर्नुहोस)। गत बैशाख १२ गते, नेपालको पश्चिम क्षेत्रमा महाभूकम्पको सम्भावना व्यक्त गरिएको क्षेत्रभन्दा पूर्व तथा सन १८३३ मा गएको विनासकारी भूकम्प (म्याग्नेच्यूड ७.६) को अनुमानित श्रोतक्षेत्र (रोजर विल्हम, १९९५) बाट एक शक्तिशाली तथा विनासकारी भूकम्प (मोमेन्ट म्याग्नेच्यूड ७.८, यूयसजिएसका अनुसार) गयो। गत वैशाख १२ गते गएको विनासकारी भूकम्प, महाभूकम्प जानसक्ने भनेर अनुमान गरिएको नेपालको पश्चिमी क्षेत्रभन्दा वाहिर (पूर्वतर्फ) गएता पनि, उक्त भूकम्पको म्याग्नेच्यूड अनुसार यस भूकम्पको श्रोत क्षेत्रको लागि यो अनपेक्षित भूकम्प भने होइन किनभने उक्त क्षेत्रमा १८३३ पछी ठूला भूकम्प गएको पाइदैन।

गोरखा भूकम्प

गत बैशाख १२ गते शनिवारको दिन बिहान ११ वजेर ५६ मिनेट जाँदा काठमाण्डौ लगायत गोरखा देखि पूर्व दोलखा सम्मका क्षेत्रहरूमा शक्तिशाली कम्पन महशुस भयो। खानी तथा भूगर्भ विभागको राष्ट्रिय भूकम्प मापन केन्द्रले उक्त कम्पनको केन्द्रविन्दू (चित्र १) गोरखा जिल्लाको वारपाकमा रहेको र यस भूकम्पको लोकल म्याग्नेच्यूड ७.६ रहेको जानकारी गरायो भने अमेरिकी भौगर्भिक सर्वेक्षण संस्था (USGS) ले उक्त भूकम्पको मोमेन्ट म्याग्नेच्यूड ७.८ जनाएको छ (लोकल म्याग्नेच्यूडभन्दा मोमेन्ट म्याग्नेच्यूड बढी आधुनिक तथा वैज्ञानिक रहेकोले यस लेखमा मोमेन्ट म्याग्नेच्यूड प्रयोग गरिएको छ)। यस भूकम्पको केन्द्रविन्दू इन्टेन्सिटी VIII रहेको पाईएको छ भने काठमाण्डौ उपत्यकामा भने VI देखि VII सम्म रहेको छ। यस भूकम्पले हालसम्म हजारौं मानिसको ज्यान लिइसकेको छ भने यो संख्या अझैं बढने क्रममा छ।

ठूलो भूकम्प जाँदा जमिन चिरिने वा फाटने प्रक्रियाको सुरुवात कुनै एक ठाउँमा हुन्छ जसलाई सतहमा इपिसेन्टर भनिन्छ तर यथार्थमा गहिराइमा रहेको भौगर्भिक दरारमा भने एउटा ठूलो क्षेत्रमा विस्थापन हुन्छ अर्थात भौगर्भिक दरारको एक भाग अर्को भागमाथि सर्दछ। हालसम्म गएका परकम्पहरूको भौगोलिक वितरणको आधारमा वैशाख १२ गते गएको भूकम्पले गोरखादेखि पूर्वतिर दोलखासम्मको करिव १४० किलोमिटर र दक्षिणमा काठमाण्डौको अक्षांस सम्म

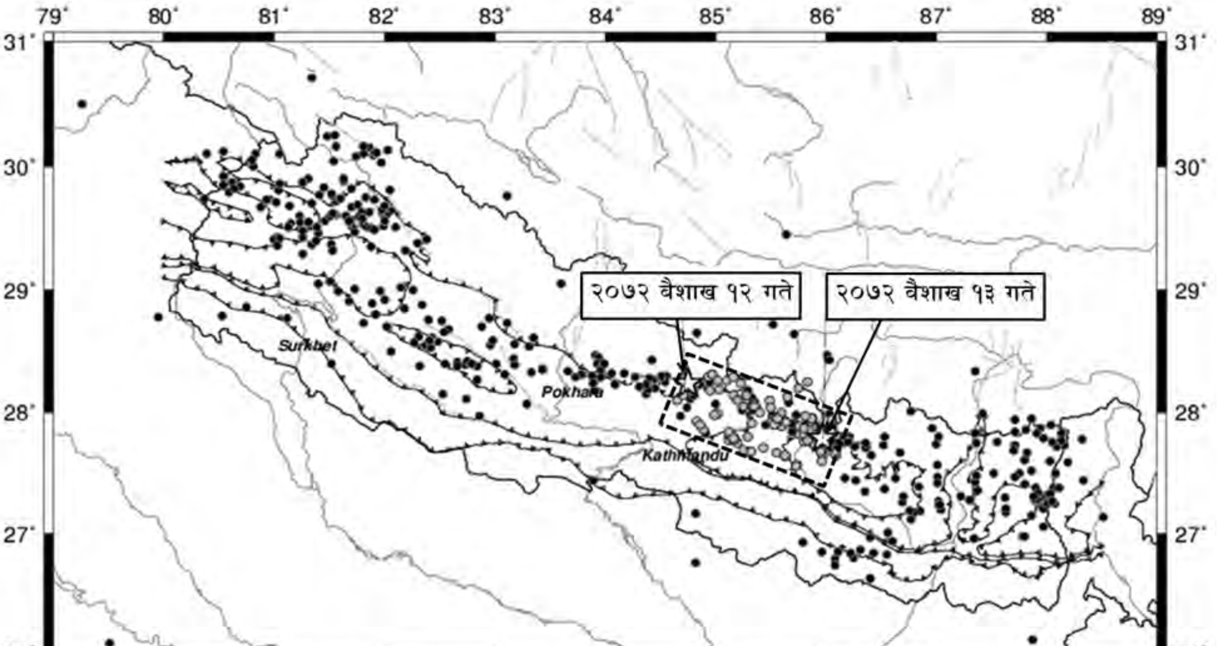
करिव करिव ४० किलोमिटरको भूभाग (चित्र १ मा देखाइएको आयताकार क्षेत्र) मुनि रहेको भौगर्भिक दरार (Main Himalayan Thrust) मा विस्थापन भएको अनुमान गर्न सकिन्छ। यसरी विस्थापन भएको क्षेत्रभरी, भूगर्भको गहिराइमा चट्टान फुटेकोले उक्त क्षेत्रभरी परकम्पनहरू गइरहेकाछन र जाने क्रम जारी छ । गोरखा भूकम्प जाँदा, जमिनमुनि, भौगर्भिक दरारको सतहमा विस्थापन भएको क्षेत्रमाथी काठमाण्डौ उपत्यका पनि पर्ने भएकोले काठमाण्डौ उपत्यकामा पनि परकम्पका केन्द्रविन्दूहरू परेका छन। वैशाख १२ गते ठूलो भूकम्प जानासाथ हामीले काठमाण्डौ उपत्यकामा महशूस गरेका, छोटो अवधीका तर आवाज सहित आउने, भूकम्पका बलिया झडकाहरू काठमाण्डौमुनि गएका भूकम्पहरू हुन। यो लेख तयार गर्दासम्म काठमाण्डौ उपत्यकामा यस्ता भूकम्पहरू (लोकल म्याग्नेच्यूड ४ वा भन्दा ठूला) को संख्या ८ पुगेको छ।

गत बैशाख १२ गते शनिवारका दिन गएको म्याग्नेच्यूड ७.८ को भूकम्प पश्चात सयौंको संख्यामा परकम्पहरू (चित्र १ र २ हेर्नुहोस) गएका छन जसमा म्याग्नेच्यूड ६ भन्दा ठूला दुई वटा परकम्पहरू छन। वैशाख १२ गते गएको मूख्य भूकम्पपछी पहिलो ठूलो परकम्प (म्याग्नेच्यूड ६.५) गोरखामा बैशाख १२ गते गएको थियो भने अर्को शक्तिशाली परकम्प (म्याग्नेच्यूड ६.९) १३ गते दोलखा क्षेत्रमा गएको थियो। ठूलो शक्तिशाली भूकम्प गएको कारणले भौगर्भिक दरारको ठूलो क्षेत्रमा विस्थापन भएर जम्मा भएको उर्जा विसर्जन हुँदा नयाँ खालको दवाव परिस्थिति उत्पन्न भएको छ, जसको कारणले परकम्पहरू अझै केही महिना सम्म जानसक्छन।

अहिलेसम्म उपलब्ध विभिन्न वैज्ञानिक तथ्यहरूको आधारमा, हालै गएको विनासकारी भूकम्पको श्रोतक्षेत्र तथा यसको आसपासमा सन १८३३ (म्याग्नेच्यूड ७.६) र १९३४ (म्याग्नेच्यूड ८.१) मा दुई ठूला भूकम्पहरू गइसकेको र हालै समेत गोरखामा विनासकारी भूकम्प गएको कारणले हाल गएको भूकम्पको श्रोतक्षेत्रबाट छिटै अर्को र अझ ठूलो भूकम्प आउने सम्भावना तत्कालको लागि कम छ तर पनि बिश्वका अन्य स्थानमा गएका भूकम्प र परकम्पहरूको तथ्यांक विश्लेषण गर्दा गोरखा भूकम्पको प्रसंगमा म्याग्नेच्यूड ७ सम्मको परकम्प जानसक्ने सम्भावना भने रहन्छ।

ठूला भूकम्प जाँदा, यस क्षेत्रमुनि रहेको विस्थापन हुने सतह (Main Himalayan Thrust) भन्दा माथिल्लो भाग विस्थापन हुँदै दक्षिणमा रहेको चुरे श्रृंखला र भावरको विचमा रहेको भौगर्भिक दरार (Main Frontal Thrust) सम्म पुग्ने गर्दछ, जहाँ उत्तरतर्फको भाग दक्षिणतर्फको भागमाथि सरेको हुन्छ। गोरखा भूकम्पको समयमा जमिनमुनि रहेको विस्थापन हुने सतह मा भने काठमाण्डौ उपत्यकाको दक्षिणसम्म मात्र विस्थापन भएको पाईएकोछ अर्थात विस्थापन Main Frontal Thrust सम्म पुगेको छैन र भूकम्पको क्रममा जति शक्ति क्षय हुनुपर्ने हो नभएको अनुमान छ। हाल काठमाण्डौ उपत्यकाको दक्षिणमा बाँकि शक्ति शञ्चय भएर रहेको देखिएको हुँदा उक्त शक्ति कसरी क्षय हुन्छ भन्ने कुरा थप अनुसन्धानको विषय भएको छ।

गोरखामा गएको भूकम्पको कारणले गोरखा देखि पूर्वमा बढी क्षति र पश्चिममा कम क्षती भएको देखिएको छ। यस भूकम्प तथा यसले गराएको क्षतिको सन्दर्भमा भन्नुपर्दा, भूकम्पको केन्द्रविन्दू गोरखाको वारपाक रहेता पनि भूकम्प उत्पन्न गरेको भनेर अनुमान गरिएको भौगर्भिक दरार (Main Himalayan Thrust को भाग) उक्त स्थानबाट पूर्वमा दोलखा जिल्ला तथा दक्षिणमा काठमाण्डौ उपत्यकाको दक्षिणी अक्षाँस सम्म रहेको क्षेत्रमुनि पर्दछ। कुनैपनि भूकम्प जाँदा भूकम्पले विस्थापन गरेको क्षेत्रमा बढी कम्पन हुने कारणले गर्दा गोरखा भूकम्पको समयमा पनि उक्त भूकम्पले विस्थापन गरेको क्षेत्रमा तिब्र कम्पन भएको हो। यही तिब्र कम्पनको कारणले बढी क्षति गोरखा र दोलखाको विच वा आसपासमा रहेका लमजुङ, धादिङ, नुवाकोट, काठमाण्डौ, रसुवा,



चित्र १.: सन १९९४ यता गएका म्याग्नेच्यूड ४ वा भन्दा ठूला भूकम्पहरू (कालो रङको वृत्त)। त्यसैगरी खैरो रङका वृत्तहरू बैशाख १२ देखि बैशाख १७ गते सम्म गएका परकम्पहरू हुन (केन्द्रविन्दू श्रोत: खानी तथा भूगर्भ विभाग : www.seismonepal.gov.np)।

सिन्धुपाल्चोक तथा पूर्वमा रामेछाप जिल्लामा केन्द्रित रहेको हो ।

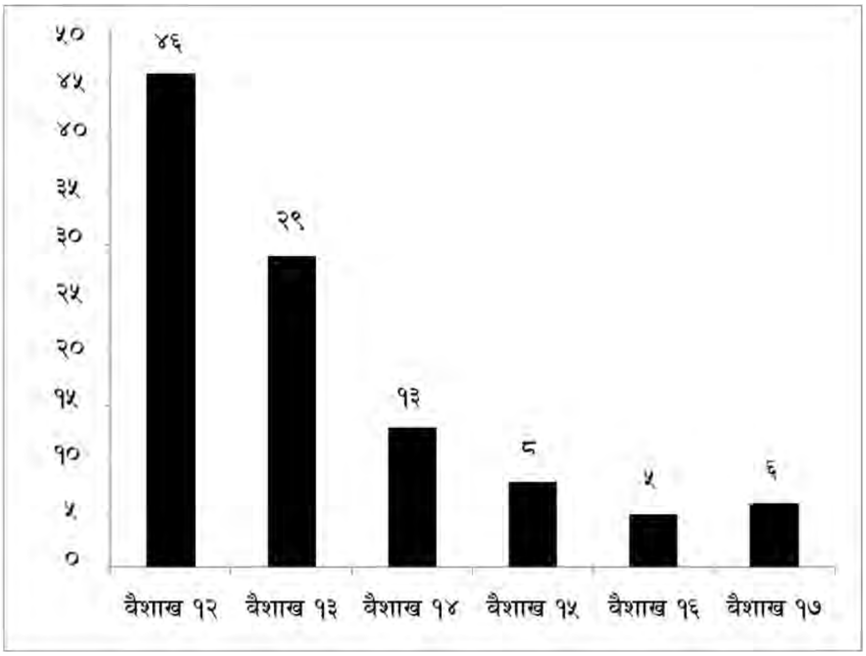
कुनैपनि भूकम्पबाट कुनैपनि स्थानमा हुने क्षतिमा, उक्त भूकम्पको म्याग्नेच्यूड वाहेक, स्थानबिशेषमुनि रहेको भूगर्भको पनि भूमिका हुन्छ। काठमाण्डौ उपत्यका, भौगर्भिक इतिहासमा एक ताल थियो जसमा यसको वरिपरिबाट आउने खोलाहरूले माटो तथा वालुवा वगाएर ल्याएर उक्त ताल भरिएको हो । भूकम्पका तरंगहरू चट्टानबाट कमलो माटोमा (वालुवा, कालो माटो) प्रवेश गर्दा भूकम्पको कम्पनको तिब्रता बढनुका साथै कम्पनको अवधी र कम्पनको frequency pattern मा पनि परिवर्तन हुन जान्छ। सामान्यतया, भूकम्पका तरंगहरू चट्टानबाट कमलो माटोमा (वालुवा, कालो माटो) प्रवेश गर्दा केही निश्चित frequency हरूको amplitude बढछ भने कम्पन अवधी पनि बढन जान्छ । यसका साथै high frequency हरू क्षय भएर low frequency हरू हावी हुन जान्छन जसको कारणले काठमाण्डौ उपत्यकाका विभिन्न स्थानहरूमा फरक प्रकारको कम्पनको कारणले फरक प्रकारको क्षति हुन गएको अनुमान छ ।

हालसम्म गरिएका विश्लेषणबाट, काठमाण्डौ उपत्यकामा, कमलो माटोमाथि रहेका स्थानहरूमा, भूगर्भको कारणले high freequency हरूको तिव्र क्षय भएको छ भने low frequency शक्तिशाली देखिएका छन । High freequency को तिव्र क्षय भएको कारणले काठमाण्डौ उपत्यकामा रहेका, आधुनिक प्रविधिको प्रयोग गरी वनाईएका, कम तल्ला भएका घरहरूमा कम क्षति हुन पुगेको अनुमान छ भने low frequency शक्तिशाली हुनगएको कारणले अग्ला घरहरूमा तुलनात्मक रूपमा बढी क्षति हुन पुगेको हुनसक्छ । यो विश्लेषणको परिणाम वृस्तृत रूपमा निकट भविष्यमा छिटै प्रकाशन गरिने छ ।

निश्कर्ष तथा सुझाव

गोरखा भूकम्पको कारणले काठमाण्डौ उपत्यकामा सोचेभन्दा कम क्षति भएको छ। उक्त भूकम्पको क्रममा, काठमाण्डौ उपत्यकामा भूगर्भको कारणले high frequency हरूको क्षय तथा low frequency हरू हावी हुन पुगे जसको कारणले आधुनिक प्रबिधि प्रयोग गरि वनाइएका होचा घरहरूमा कम क्षति भयो भने अग्ला घरहरूमा तुलनात्मक रूपमा बढी असर पुग्न गयो । अपवादको रूपमा केही स्थानमा उक्त स्थानमुनिको भूगर्भको कारणले तथा घरहरूको वनावटमा रहेका कमी कमजोरीको कारणले अन्य स्थानमा भन्दा बढी क्षति भएको देखियो।

गोरखामा गएको शक्तिशाली भूकम्प तथा वलिया परकम्पहरूले हजारौं निर्दोषहरूको ज्यान क्षणभरमा लिएर गइसकेकाछन जसको असर पिडितहरूले



चित्र २.: २०७२ साल वैशाख १२ गते देखि १७ गते सम्म गएका परकम्पहरू (डाटा श्रोत : खानी तथा भूगर्भ विभाग, www.seismonepal.gov.np)

जीवनभर विर्सनसक्ने छैननभने देशको अर्थतन्त्र र विकासको गतिलाई यसले दशकौं पछाडी धकेलिदिएको छ । भूकम्पलाइ हामी रोक्न सक्दैनौं र यसको भविष्यवाणी पनि गर्न सक्दैनौ तर भूकम्पबाट हुने क्षति भने कम गर्न सकिन्छ जसको लागि हामिले भकम्पबाट क्षति हुन नसक्ने भूकम्प प्रतिरोधी भवन तथा संरचनाहरूको निर्माण गर्नु आवश्यक छ । भूकम्पबाट सुरक्षित रहन हामी वस्ने धरमात्र बलियो भएर पुग्दैन हामीले कामगर्ने कार्यालय, कारखाना, हाम्रा छोराछोरीले पढने विद्यालय, कलेज, विरामीको उपचार गर्ने अस्पतालहरू तथा ठूलो संख्यामा मानिसहरू जम्मा हुने हलहरू समेत भूकम्प प्रतिरोधी हुन आवश्यक छ।

हालै गएका भूकम्पहरूबाट प्राप्त विभिन्न किसिमका जानकारीहरूको उपयोग गर्दै विद्यमान भूकम्प जोखिम अनुमान नक्सा तथा निर्माण संहिताको आवश्यक परिमार्जन गर्नु आजको प्रमुख आवश्यकता हो । यसैगरी भवनहरू तथा अन्य संरचनाहरूको क्षति हुनुमा स्थान विशेषमुनीको भूगर्भको पनि भूमिका भएको देखिएकोले भवन लगायत सवै किसिमको भौतिक निर्माण गर्नुपूर्व भूगर्भविद र भूकम्पविदको पनि अनिवार्य राय लिनुपर्ने गरि नीति नियमको तर्जुमा हुन जरुरी भइसकेको छ ।

गोरखा भूकम्प र यसका परकम्पहरूले छोडेर गएको अवस्थाले हामीलाई एक शिक्षा दिएको छ जसवाट पाठ सिकेर दिर्घकालिन सोचकासाथ, आवश्यक नीति नियमहरूको तर्जुमा, भएका नीति नियमहरूको परिमार्जन तथा भूकम्प प्रतिरोधी संरचनाहरूको निर्माण गरेर सुरक्षाको सुनिश्चितता सहितको भविष्य हाम्रा भावी पिंढीहरूलाई हस्तान्तरण गर्न हामीले हाम्रो सोचाइ र व्यवहारमा आमूल परिवर्तन गर्न जरुरी छ ।

यसका साथै, हाम्रो देशमा वैज्ञानिक अनुसन्धानकार्य गर्न गराउन खासै महत्व दिएको पाइँदैन । अनुसन्धानकार्यमा नयाँ पिंढीहरूलाई आकर्सित गर्नकोलागि नीति निमार्णतहमै पुनर्विचार गरेर प्रतिभाशाली, क्षमतावान अनुसन्धानकर्ताहरूको विदेश पलायन रोक्नको लागि पहल हुन आवश्यक छ ।

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भू-वैज्ञानिक कार्यरत क्षेत्रहरू, भू-विपद अनुसन्धान केन्द्र तथा भौगर्भिक काउन्सिलको आवश्यकता

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सारांश

भू-विज्ञान केवल भू-बैज्ञानिकहरू को लागि अनुसन्धानको विषयवस्तु मात्र नभई विभिन्न प्राकृतिक श्रोतको अन्वेषण तथा उत्खनन गर्ने लगायत विकाश निर्माणका हरेक गतिविधिका लागि एक अपरिहार्य बिषय भएकोमा कसैको द्विमत हुन सक्तैन। तर विडम्बना, नेपालमा यस विधाको महत्व आत्मसात गरि यसको उपयोग प्रचुर मात्रामा हुन नासकेको कारणले गर्दा खानि जन्य प्राकृतिक श्रोतको उचित अन्वेषण तथा उत्खनन हुन नसकेको स्थिति छ। साथै विकाश निर्माणका गतिविधिहरूमा पनि यस विधालाई उचित स्थान दिन नसकेको कारणले हामीले निर्माण गरेका संरचनाहरूको दिगोपनमा असर पर्नेगरेको हामीले अनुभव गरेका छौं। सरकारी संरचनामा पनि यस विधा लाई कम महत्व दिएको अवस्थाले गर्दा भू-वैज्ञानिकको यथोचित पदस्थापन हुन नसकी यस विधा को अधिकतम उपयोग हुनसकेको देखिँदैन। यसको अलावा, भू-बैज्ञानिकहरूको बढ्दो संख्या, विधागत विषेसग्यता र संलग्न हुन सक्ने क्षेत्र बिस्तारित भईरहेको अवस्थामा एउटा भरपर्दो नियमन र अनुगमन गर्ने निकायको खाँचो महसुस भएको छ। यिनै विषयवस्तुलाई यस आलेखमार्फत प्रस्तुत गर्ने जमर्को गरिएको छ।

भू-बैज्ञानिक कार्यरत क्षेत्रहरू

भू-बैज्ञानिकहरूले भू-विज्ञानका विभिन्न विधाहरू जस्तै आधारभूत भूगर्भ विज्ञान, भूमिगत जलश्रोत, ईन्जीनियरिंग भूगर्भ विज्ञान, माइनिंग भू-विज्ञान, माइनिंग ईन्जीनियरिंग, भू-भौतिक विज्ञान लगायतका विधाहरूमा आ-आफ्नो ज्ञान र दक्षता अनुसारको विषयगत योगदान दिइरहेका छन्। साथै यी विधाहरूलाई भू-विपद अध्ययन अनुसन्धान कार्यमा पनि प्रचुर मात्रामा प्रयोग गरिएकोछ। नेपालमा भू-बैज्ञानिकहरू प्राज्ञिक, सरकारी, अर्ध-सरकारी, गैरसरकारी तथा निजि क्षेत्रमा कार्यरत रही आएका छन्।

त्रिभुवन विश्वविद्यालयमा स्नातक र स्नातकोत्तर तहमा भूगर्भ विज्ञानको अध्यापन हुनेगरेको छ जहाँ भूगर्भ विज्ञानका विभिन्न विधाहरूमा विसेषग्यता हासिल गरेका भूगर्भ शास्त्रीहरू प्राध्यापनमा सक्रिय छन्। यस प्राज्ञिक निकायमा विश्वविद्यालयको तर्फबाट वा राज्यको तर्फबाट अध्ययन-अनुसन्धानमा खासै कुनै लगानी हुन सकेको छैन। प्राज्ञिक क्षेत्रमा केवल अध्यापन गर्ने मात्र नभई अनुसन्धान पनि गर्नु पर्छ भन्ने विषयलाई राज्यले आत्मसात गर्न सकेको छैन।

नेपाल हिमालयको विशिस्ट भौगर्भिक बनोट, भौगोलिक अवस्थिति तथा जलवायुको कारणले गर्दा हामीले जल उत्पन्न प्रकोप को समस्या नियमित जस्तै सामना गर्नु पर्ने वाध्यता छ। यसको लागि नेपाल सरकार, सिंचाई मन्त्रालय अन्तर्गत जल उत्पन्न प्रकोप नियन्त्रण विभागमा इन्जिनियरिंग सेवा अन्तर्गत इन्जिनियरिंग भूगर्भ विज्ञान उप समूह तथा भूमिगत जलश्रोत उप-समूह अन्तर्गतका सिमित संख्यामा भू-बैज्ञानिकहरू केन्द्रिय कार्यालयमा कार्यरत छन्। यस विभागका ७ वटा डिभिजन र ५ वटा सब-डिभिजन कार्यालयले देशभरकै जल उत्पन्न समस्या सम्बोधन गर्नुपर्ने अवस्थामा केन्द्रीय कार्यालयमामात्र न्युन संख्यामा कार्यरत भू-वैज्ञानिकले देशभरकै जल उत्पन्न प्रकोप नियन्त्र कार्यमा त्यति प्रभाबकारी योगदान दिनसक्ने वातावरण छैन। वन मन्त्रालय अन्तर्गतको भू तथा जलाधार संरक्षण विभागले केन्द्रीय कार्यालय लगायत ५६ वटा जिल्ला भू-संरक्षण कार्यालय मार्फत देशभरकै भू तथा जलाधार संरक्षण को क्षेत्रमा क्रियाशील हुनुपर्ने जिम्मेवारी पाएको विभाग हो। दुर्भाग्य यो छ कि यस बिभागको केन्द्रमा केवल १ जना भूगर्भशास्त्रीको उपस्थितिले मुलुकभरको भू-संरक्षण कार्यमा भौगर्भिक ज्ञानको उपयोग हुन नसक्दा भू-तथा जलाधार संरक्षण कार्य प्रभाबकारी हुन नसकेको र यहि स्थिति रहेमा भविष्यमा पनि कुनै सुधार हुन नसक्ने निश्चित छ।

सडक विभागमा भूगर्भविदको उपस्थिति शून्य छ जबकी राजमार्ग तथा पुल निर्माण कार्यमा भूगर्भशास्त्रीको संलग्नता अनिवार्य गरिएको छ। तर आफूसँग सो जनशक्ति अभाव हुँदा परामर्शदातृ संस्थाले सीमित अवधिका लागि र सीमित कार्यका लागिमात्र उपलब्ध गराएको परामर्शदाता भूगर्भशास्त्रीमा मात्रै निर्भर रहनुपर्ने बाध्यता विद्यमान छ। भूगर्भविदका लागिमात्र हाम्रा सरकारी निकाय परामर्शदातृ संस्थाले उपलब्ध गराएको जनशक्तिमा मात्र निर्भर हुने व्यवस्थाले यस महत्वपूर्ण विधालाई अन्याय गरेको छ।

पूर्वाधार विकाससम्बन्धी कार्य मुख्यतः कृषि तथा ग्रामीण सडक, सिँचाई, नदी नियन्त्रण, खानेपानी तथा सरसफाइ, झोलुङ्गे पुल, आवास तथा भवन, ग्रामीण ऊर्जा लगायतमा महत्वपूर्ण भूमिका निर्वाह गर्ने अर्को सरकारी निकाय स्थानीय पूर्वाधार विकास तथा कृषि सडक विभाग हो। पूर्वाधार निर्माणमा आवश्यक पर्ने भौगर्भिक दक्षता भएका कुनै पनि प्राविधिकको संलग्नताबिना नै यस विभागले आफ्ना कार्यक्रम सञ्चालन गरिरहेको देखिन्छ।

खानेपानी संस्थान र खानेपानी तथा ढल निकास विभाग मा कुनैपनि भू-बैज्ञानिकको उपस्थिति छैन जब कि पहाडी भागमा भूमिगत जलश्रोतको उपयोगको लागि यस विधाको जरूरत पर्दछ। त्यस्तै भूमिगत जलश्रोत विकाश समितिको कार्यक्षेत्र विशेष रूपमा तराईका जिल्लामा र त्यो पनि सिंचाइ प्रयोजनको लागि लक्षित भई व्यवहारिक रूपमा साँघुरिन पुगेको छ। अनुसन्धानबिना विकाश सम्भब हुदैन भन्ने यथातालाई बिर्सी यो समिति भूमिगत जल दोहनमा मात्रै सिमित हुन पुगेको छ र पहाडी भागमा यसको गतिबिधि न्यून छ।

भू-विपद अनुसन्धान केन्द्र को आवश्यकता

नेपालको भौगोलिक अवस्थिति र भौगर्भिक बनोट को कारण यहाँ प्राकृतिक विपदको उच्च जोखिम छ साथै बिगतमा हामीले धेरै पटक विभिन्न खाले विपदको सामना पनि गरि सकेका छौ । समय समयमा उत्पन्न भएका भू-विपद (Geo-disaster) को अवस्थामा भूगर्भशास्त्रिको आवश्यकता तथा उपयोगिता सम्बन्धमा विभिन्न स्तरमा छलफलभई यसको महत्व उजागर हुनेगरेको तर अन्य समयमा यस महत्वपूर्ण विधा ओझेलमा परेको हामीले अनुभब गरेको छौं । यसको ज्वलन्त उदाहरणमा पोखराको सेती नदीको बाढी, अर्मलाको जमिन भासिएको घटना र सिन्धुपाल्चोकको जुरे पहिरो पछिको अवस्थालाई लिन सकिन्छ ।

भू-बैज्ञानिकहरूको संलग्नता भू-विपदसंग सम्बन्धित विभिन्न चरणका अध्ययन-अनुसन्धान लगायत भू-विपद न्यूनीकरणका विभिन्न चरणहरूमा रहनेकुरा अहिलेको अवस्थामा हामी सबैले बोध गरिसकेका छौ र यसलाई आत्मसात गरेर ब्यबहारमा ल्याउने कार्यलाई प्रभाबकारी बनाउन जरूरी छ । यसै सम्बन्धमा विश्वविद्यालयमा भू-विपद अनुसन्धान केन्द्र (Geo-disaster Research Center) स्थापना गरि यसलाई राज्यको तर्फबाट भू-विपद अध्ययन अनुसन्धानको लागि जिम्मेवार निकायको रूपमा विकाश गरि यस केन्द्र लाई मुलुकमा विद्यमान विभिन्न Geo-hazards को अवस्थाको अध्ययन तथा नक्सांकन गर्ने तथा भू-विपद को सम्भाब्य स्थानको पहिचान गर्ने जिम्मेवारी दिने र उक्त स्थानहरूमा सरकारी निकाय ले भू-विपद न्यूनिकरणको लागि केन्द्रसंगको समन्वयमा आवश्यक संरचना निर्माण गर्ने लगायतका काम गर्ने व्यवस्था गर्नु उचित हुन्छ । यस किसिमको व्यवस्थाले भू-विपद न्यूनीकरण कार्यलाई बढी व्यवस्थित, चुस्त र उपलब्धिमूलक बनाउनेछ । यस किसिमको व्यवस्था भू-विपदको उच्च जोखिममा भएका अन्य मुलुकमा पनि भएको र सो प्रभाबकारी भएकोमा हामी सबै जानकार नैं छौं ।

भौगर्भिक काउन्सिलको आवश्यकता

पूर्वाधार निर्माण लगायतका कार्यहरूमा भू-बैज्ञानिकहरूको महत्वपूर्ण भूमिका रहने हुँदा सो कार्यमा संलग्न भू-बैज्ञानिक सम्बन्धित विधा अध्ययन गरेको र अनुभवी हुनु जरूरी छ । तसर्थ भू-बैज्ञानिकको सेवा प्रदान गर्ने कुनै पनि कार्यमा भू-बैज्ञानिकको संलग्नता, निजको योग्यता तथा पेशागत दक्षताको नियमन र अनुगमन गर्ने निकायको अत्यन्त खाँचो छ । हाल कुनै पनि काउन्सिलको सदस्यता लिनुपर्ने बाध्यकारी अवस्था नभएको हुँदा कुनै पनि कार्यमा वास्तविक भू-वैज्ञानिकको संलग्नता भए-नभएको अनुगमन कार्य कमजोर हुने र भू-बैज्ञानिकको संलग्नता नैं भएको अवस्थामा पनि निजले पेशागत मर्यादा अबलम्बन गरे-नगरेको जाँच-बुझ गर्ने र लापरबाही भएको खण्डमा कारबाही गर्ने निकायको अभाब छ । महत्वपूर्ण आयोजनामा भौगर्भिक अध्ययन कमजोर भई आयोजनाको लागत बढ्न गएको साथै पूर्ब-निर्धारित समयमा सम्पन्न हुन नसकेको उदाहरणहरू प्रसस्त छन् । हाल विद्यमान नेपाल इन्जिनियरिंग काउन्सिलले भुगर्भ बिज्ञानलाई समेट्न नसकेको अवस्थामा विभिन्न विधाहरूका भू-बैज्ञानिकहरूको पेशागत अधिकार सुनिस्चित गरि उनीहरूलाई बढी जिम्मेबार बनाउनकालागि भौगर्भिक काउन्सिल स्थापना गर्न ढिलाई भैसकेको छ ।

निस्कर्ष र सुझाब

हाम्रा सरकारी निकायहरू, तिनिहरूबाट संचालित हुने कार्यक्रम, उक्त कार्यक्रम संचालन गर्दा सामना गर्नुपर्ने भू-विपदको सम्भावना र ती निकायहरूमा भूगर्भशास्त्रिको उल्लेख्य संलग्नता हुनको लागि निजहरूको उचित पदस्थापन हुनु जरूरी छ । पुर्बाधार विकाश संग सम्बन्धित सबै सरकारी निकायमा भूगर्भबिदको उल्लेख्य व्यवस्था र उचित जिम्मेवारी दिने व्यवस्था गर्ने हो भने भौगर्भिक कारणबाट सिर्जना हुन सक्ने समस्यालाई समयमैं न्यूनीकरण गर्न सकिन्छ । त्यसै गरि स्थानीय निकायहरूमा (कमसेकम प्रत्येक जिल्ला विकाश समितिमा एक जना) भूगर्भविदको व्यवस्थाले सम्बन्धित जिल्लामा हुने पूर्वाधार निर्माण लगायतका कार्यमा भौगर्भिक ज्ञानको उपयोग हुनगई ति योजनाहरूको दिगोपनामा सकारात्मक प्रभाव पर्दछ ।

भू-विज्ञानका विभिन्न विधाहरूमा अध्ययन अनुसन्धान लाई राज्य स्तरबाट नैं उच्च प्राथमिकता दिनु आवश्यक छ र त्रिभुवन विश्वविध्यालयको भूगर्भ विभागलाई अनुसन्धानकार्य (विशेष गरि नेपाल हिमालयमा) को लागि आवश्यक सहयोग र प्रोत्साहन गरि यस विधालाई राज्यले देश विकाशको कार्यहरूमा भरपुर उपयोग गर्न सक्ने जनशक्ति उत्पादन गर्न सक्षम बनाउनु राज्यको लागिपनि हितकर छ । भू-विपद न्यूनीकरण कार्यलाई प्रभाबकारी बनाउन त्रि.वि. भूगर्भ विभाग मार्फत भू-विपद अनुसन्धान कार्यलाई राज्यको तर्फबाट प्राथमिकताका साथ आवश्यक सहयोग हुनु पर्छ । भूगर्भ बिज्ञानलाई नेपाल इन्जिनियरिंग काउन्सिलले समेट्न नसकेको अवस्थामा भौगर्भिक काउन्सिल (Geological Council) को स्थापना गर्नु अत्यन्त जरूरी छ ।

Sediment rating models for damsite of Seti River of Tanahun Hydropower Project

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ABSTRACT

Rivers transports natural sediment, which varies with time. Human made structures such as dams across the rivers obstruct this natural pattern of sediment transport. In a result, reservoirs act as sediment trappers in the rivers. The inflow and outflow difference of sediments will estimate the quantity of trapped sediment in the reservoir. Hence, the deposited sediment in the reservoirs is difficult to measure practically. To estimate the correct volume of reservoir sedimentation, the selection of sediment rating curve is very important. Hence, in this study, two types of models namely sediment rating curve and multiple linear regression are tested for measured data in Seti reservoir site of Tanahun Hydropower Project. The result shows that the sediment rating curve is giving better results than multiple linear regression method.

INTRODUCTION

Sedimentation is a natural phenomenon. Rivers transports natural sediment, which varies with time. Human made structures such as dams across the rivers obstruct this natural pattern of sediment transport. In a result, reservoirs act as sediment trappers in the rivers. The inflow and outflow difference of sediments will estimate the quantity of trapped sediment in the reservoir. Hence, the deposited sediment in the reservoirs is difficult to measure practically. According to which helps to maintain the regulation of water to supply either irrigation purpose or hydropower use or else. Usually the life span of reservoirs is determined by the rate of sedimentation, which gradually reduces the storage capacity and eventually eliminates the ability of the reservoirs to provide water for multiple uses. This means the availability of water volumes in reservoirs will decrease each year of operation. As a result, the reservoir operation policy for each time span in the life period will be varied. Hence, correct estimation of sediment volume carried out by river is very important for many water resource projects. To estimate the correct volume of reservoir sedimentation, the selection of sediment rating curve is necessary. In this paper, some of the modeling techniques for the sedimentation-discharge relation are discussed. SRC and MLR techniques are applied to the case study of Seti River having at the dam site of Tanahun Hydropower Project.

MODELING TECHNIQUES IN SEDIMENTATION

Basically, the sediment rating curve (SRC) and stage-discharge rating curve (RC) are based on same principle. The modeling technique like sediment rating curve (SRC) and multiple linear regression (MLR) techniques are applied in this study. Many soft computing techniques like MT and GEP also used in sediment rating (Reddy and Ghimire, 2009), however SRC and MLR has equal and powerful implications in this field.

Sediment rating curve (SRC)

Basically, the sediment rating curve (SRC) and stage-discharge rating curve (RC) are based on same principle. However the real difference is in stage-discharge rating curve there is additional constant (stage) corresponding to zero discharge and in sediment rating curve there is no additive or subtractive constant in discharges. Normally concentration will be related with the help of discharge and then converted to estimate the sediment load and yield which is not always mandatory. Equation (1) is the basic relation between discharge and sediment load.

$$S = aQ^b \qquad (1)$$

Where, S and Q are sediment load and discharge, *a* and *b* the relational constants depends on stream sections. The constants determine by using linear regression after the log-log plot of sediment load and stream discharge. The possible error during log transformation of parameters is eliminated by introducing the correction factor '*CF*' popularly known as log transformation bias correction factor. After correction Equation (2) modified in the form of Equation (3).

$$S = CF.a.Q^b \qquad (2)$$

The log-transformation bias correction factor (*CF*) proposed by Ferguson (1986) is given by-

$$CF = e^{2.651s^2} \qquad (3)$$

Where, *e* and *s* stands for exponential function and standard error for regression after log transformation respectively.

Multiple linear regression (MLR)

In research while predicted values coincide with the observed values, then their correlation coefficient will be unity

and having the null root mean square error (RMSE). However, practically, this hypothetical assumption not occurs usually. The simple linear regression graphs help the validity of the predicted results. Linear regression is described by following relations-

$$y_i = \alpha_0 + \alpha_1 x_i + R \qquad (4)$$

Where, *R* is *random* number (generated by any one suitable method), α_0 and α_1 are defined as intercept and slope constants of regression line, given by:

$$\alpha_0 = \frac{\sum x_i y_i}{n} - \frac{\alpha 1 \sum x_i}{n} \qquad (5)$$

and

$$\alpha_1 = \frac{\sum x_i y_i - \sum x_i \sum y_i / n}{\sqrt{\sum x_i^2 - \left(\sum x_i\right)^2 / n}} \qquad (6)$$

Where n is the no of variables in either set.

In application, while independent variable becomes only one data set, then the relation becomes the MLR becomes linear regression only.

CASE STUDY

Like other rivers flowing from higher mountainous region, the Seti River also carrying the sediment sufficiently. The rivers of Nepal are known to be carrying heavy loads of sediments in a huge variety of grain sizes, ranging from clay to large boulders. The impact of the sediment load to the reservoir comes up and the sediment influences the reservoir life and its storage capacity.

Study area

The Seti Reservoir of Tanahun Hydropower Project is selected for the case study. The main source of the Seti River is the Annapurna Mountain with the highest peak being Annapurna III at 7455 m from average sea level (masl). The Seti River is flowing approximately middle part of the Western Development Region of Nepal.

Data used

The runoff data to the dam site (hydrology station no 430.5) from January 1, 2000 to December 31, 2006 are collected from Department of Hydrology and Meteorology (DHM) of Nepal. The sediment data and river discharges during the sediment sampling time are collected from Nepal Electricity Authority (NEA). The sediment samples and corresponding river discharges to the dam site were taken by NEA in the years 2000, 2001 and 2004 partially. These data are used for this study.

The sediment data was not available for sufficient period, however from the available data the best estimation has done. There are 208 data samples used for model development.

i. Sediment samples taken in between June 27, 2000 to Dec. 08, 2000: 121 records.
ii. Sediment samples taken in between June 26, 2001 to Sep. 28, 2001: 92 records.
iii. Sediment samples taken in between July 03, 2004 to Oct. 28, 2004: 67records.

Since there is no sufficient sediment data available for the Seti River, the nearby River called 'Marsyangdi' data are used for model development. The Marsyangdi Hydropower plant was commissioned in 1989. Its plant capacity is 69 MW and the average yearly power generation from the plant is 462.5 GWh. The natures of flows in these two rivers are similar. The catchment area at dam site is 3850 km^2. Long term average flow to the dam site is 210 m^3/s. Since from its commissioned year, the sediment and inflow data at the dam site are recorded. These data are taken from the Marsyangdi Hydropower Station. The Marsyangdi data for the corresponding dates are used for model development in the Seti River of its dam site and the other data are used for sediment prediction from 2000 to 2006 to the Upper Seti Dam site.

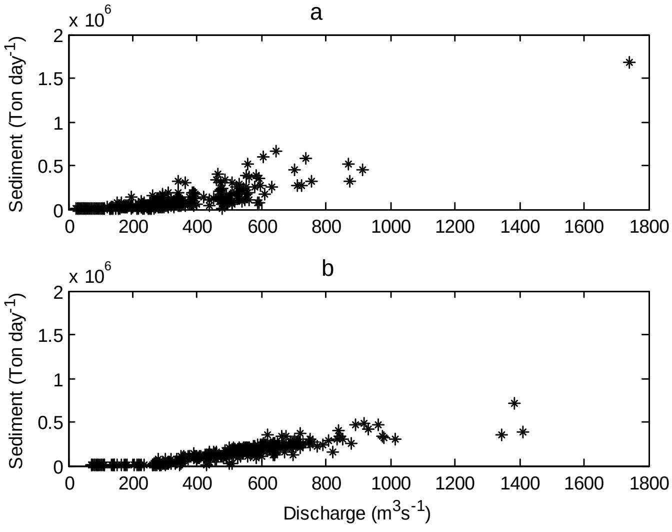

Figure 1: Scatter plot of observed discharge and daily sediment load of (a) the Seti River at Reservoir Dam site, Damauli and (b) the Marsyangdi River at Dam site, Aanboo Khaireni.

The scatter plot of observed sediment loads and discharges for both the Rivers of their Dam sites are shown in Figure 1. The plots show that the sediment loads in the Seti River of its Dam site above the discharge 1000 m^3/s are highly stochastic and only occurs during high flood events. Similarly, it can be seen from the plot that the discharge below 1000 m^3/s , the nature of the sediments occurrence are seems to be similar for both the Rivers at their corresponding Dam sites. Out of these 280 samples, 70 % data are randomly selected for training and the remaining data are used for testing the models. The statistical parameters such as μ, σ, σ/μ, C_{sx}, X_{max}, X_{min} (mean, standard deviation, sd-mean ratio, skew-ness, maximum and minimum values) are given on Table 1.

Table 1: The daily statistical parameters for training and testing data set

Data Set	Station	Basin Area (Km^2)	Data Type	μ	σ	σ/μ	C_{sx}	X_{max}	X_{min}
Training	Seti River Dam site	1502	Flow (m^3s^{-1}) Sediment (ton day^{-1})	318.3 98745.7	206.4 159718.5	0.65 1.62	2.028 5.676	1741.4 167279	25.9 8.1
	Marsyangdi Dam site	3850	Flow (m^3s^{-1}) Sediment (ton day^{-1})	503.8 145351.7	226.8 110501.8	0.45 0.76	0.593 0.959	1409.6 718609.5	72.5 62.6
Testing	Seti River Dam site	1502	Flow (m^3s^{-1}) Sediment (ton day^{-1})	309 90776.3	174.1 114075.9	0.56 1.26	0.29 2.35	712.2 590389.4	26.5 3.9
	Marsyangdi Dam site	3850	Flow (m^3s^{-1}) Sediment (ton day^{-1})	472.3 140700.4	201.6 105083.1	0.43 0.75	-0.04 0.55	975.6 465571.9	74.9 103.5

Model developed using SRC and MLR

To develop the SRC model, Microsoft Excel is used whereas to develop the MLR model a Program has been written in Matlab platform and applied. In MLR model, the independent variables consist of the sets of discharges and sediments from two different Rivers. For example, it is related as: $S_{s,t}=\{Q_{s,t}, Q_{m,t}, S_{m,t}\}$ where $Q_{s,t}$, and $Q_{m,t}$ represents time series daily discharges in m^3/s and $S_{s,t}$ and $S_{m,t}$ represents the sediments in tons per day for the Seti and the Marsyangdi Rivers respectively. As per objectives of the study, sediment in the Seti River is treated as dependent variable and discharges of both the Rivers and sediment of the Marsyangdi River are treated as independent variables. The SRC and MLR developed models are listed on the Equations (7) and (8) respectively as follows.

$$S_{s,t} = 0.0176 Q_{s,t}^{\ 2.5993} \quad \text{.......................................} (7)$$

$$S_{s,t} = 37.7279\ Q_{m,t} - 0.3887\ S_{m,t} + 787.8682\ Q_{s,t} - 114917.804 \quad (8)$$

DISCUSSION ON RESULTS

The summary of the root mean square error (RMSE) and coefficient of determination (R^2) obtained from different models are shown in Table 3. From Table 3 it is seen that SRC has good coefficient of determination value (R^2) than MLR model. So it is seen that SCR model is better than MLR model.

Table 3: Root means square error (RMSE) and Coefficient of determination (R^2) in models in training, testing and overall data

Model Based on	Training		Testing		Over all	
	RMSE	R^2	RMSE	R^2	RMSE	R^2
i. SRC	230473.6	**0.7347**	68542.0	**0.6458**	196448.6	**0.8268**
ii. MLR	89889.9	0.6870	80308.8	0.5674	87126.3	0.8132

CONCLUSION

In this study, modeling tools like SCR and MLR are applied and evaluated to establish relationships between suspended sediment load and discharge at the dam site of Tanahun hydropower project of Seti River in Nepal. It is found that the performances of SCR methods is quite good than MLR technique. SCR has the ability to formulate the data into equation form, which is easy to use in actual site, and hence it is very powerful. This formulation helps to find the sediment

load for non-gauged Seti River. Hence developed equation might be useful for sediment study in the Seti River in future.

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Integrated flood management with respect to stakeholder involvement in Nepal

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ABSTRACT

Nepal is a mountainous and landlocked country having an area of 147, 181 square kilometer. Geologically, Nepal lies at the center and the southern edge of Hindu-Kush Himalayan Region (HKH), which is the youngest geological formation in the world. So, floods and landslides are common in this region. More than 80% of the annual rainfall occurs in the monsoon season which starts from June and lasts till September in Nepal. So due to the intense rainfall that occurs within a short period, monsoon acts as the biggest cause for the occurrence of different disastrous events including flood. This is the reason why integrated flood management (IFM) is one of the important countermeasures to be implemented in the nation to reduce the adverse effect of floods. This study emphasizes on the existing conditions of IFM with respect to stakeholder involvement in the context of Nepal and it can be assured that all the highlighted issues coming out from this study will be highly beneficial to policy makers, implementing agencies and scientific as well as local communities to enhance IFM works in the nation.

BACKGROUND

Integrated flood management (IFM) is a process of promoting an integrated rather than a fragmented approach to flood management, integrating land and water resource development in a river basin within the context of integrated water resources management (IWRM), with the aim of maximizing the net benefits from flood plains while minimizing loss of life from flooding (WMO 2006). The concept of IFM was initially adopted by United Nations at the Rio Summit of 1992 (DMP 2012).

GEOGRAPHIC AND HYDRO-CLIMATIC CONDITION OF NEPAL

Nepal occupies of about 0.03 percent of the total land area of the earth and about two-third of its land area is occupied by hills and mountains. Nepal is enriched with more than 6000 rivers and streams each of whose length exceeds 45,000 kilometers (Yogacharya 1998). Elevation of the country starts from 61 meters to 8848 meters, and this 8848 meters gets its name as ***The Everest*** also known as the top of the world (Gautam 2000). On the basis of the altitude, the physiographic parts of the country are categorized into five different regions such as terai; siwalik; middle mountains; high mountains and high Himalayas (Fig. 1).

Geologically, Nepal lies in the center and at the southern edge of Hindu-Kush Himalayan Region (HKH), which is also the youngest geological formation in the world. So, floods and landslides are much common in this region. HKH region is the world's highest mountain region extending over 3500 km from Afghanistan in the west to Myanmar in the east and ranging from the Tibetan Plateau in the north to the Ganges basin in the south. The steep slopes, unstable geology and the intense monsoons combine to make the HKH region one of the most fragile and hazard-prone areas of the world.

More than 80% of the annual rainfall occurs in the monsoon season in Nepal. Due to the intense rainfall within a short period (June-September), monsoon acts as the biggest cause for the occurrence of different disastrous events including floods in the nation. Due to the unequal distribution of monsoon rainfall, chances of floods and droughts are enhanced at different parts of the nation. It can be taken as a concrete example that, in every monsoon season, floods of Bagmati devastates its downstream areas like Sarlahi, Rautahat and so on.

In 1993 during the time period of 19-21 July, heavy rainfall brought disastrous consequences in the eastern and the central regions with heavy loss of life and property as well as damages to infrastructures by floods, landslides and debris flows. Results show in 1993, 87 % of the total deaths of human life in the country resulted from floods and landslides (Yogacharya and Gautam 2008). The flood induced disaster of 1993 had affected more than 500,000 people of 85,254 families including the casualties of 1,336 people (Yogacharya and Gautam 2008). This was the worst flood induced disaster in the last 20 years.

In Nepal, from the records of 1971-2010, flood and landslide is the second biggest cause for casualties after epidemics. Detail data of the numbers of causalities recorded from 1971-2010 are given in Table 1.

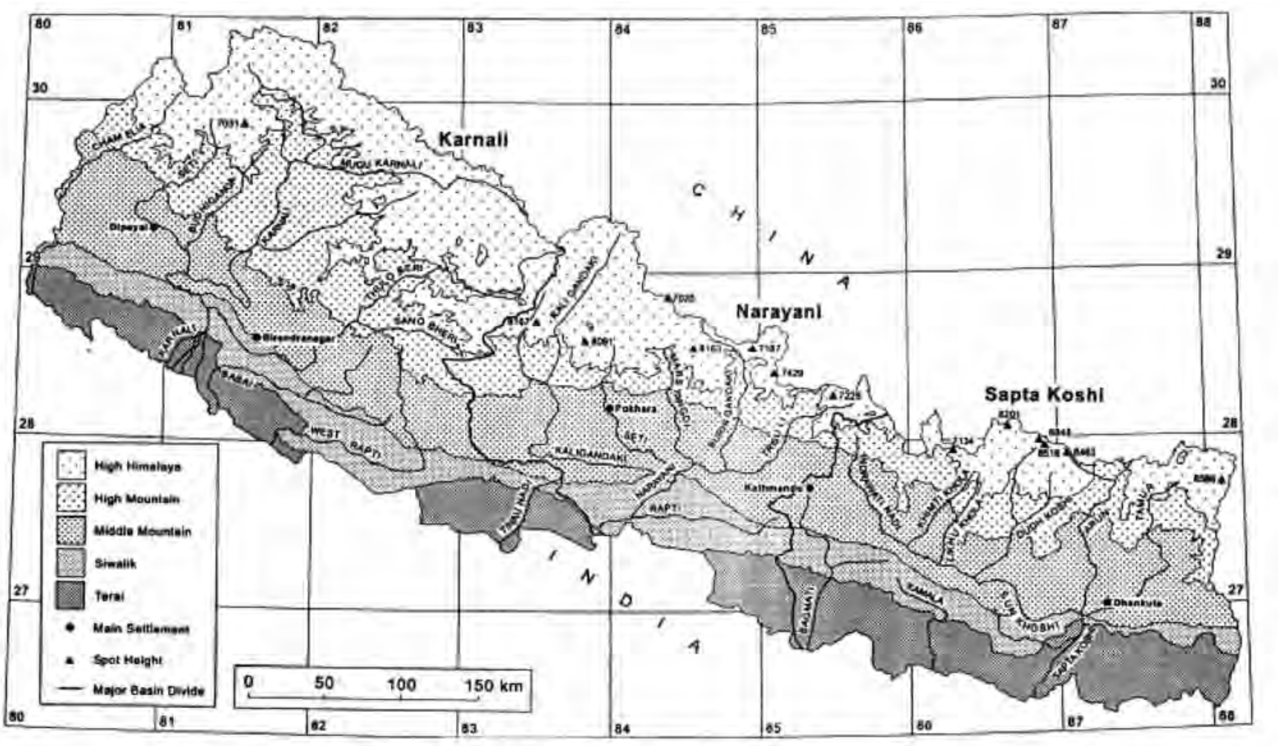

Fig. 1: Physiographic condition and river systems of Nepal (Hannah et al. 2005).

Table 1: Human life lost due to disasters in Nepal (MoHA and DPNet-Nepal 2011)

S.N.	Types of disasters	1971-2010
1	Epidemics	12,017
2	Flood and landslide	7,469
3	Fire	1293
4	Thunderstorm	986
5	Accident	969
6	Earthquake	873
7	Cold wave	442
8	Structural Collapse	404
9	Boat Capsize	269
10	Other events	999
	Total	30982

NEPAL AND STAKEHOLDER INVOLVEMENT IN IFM

Government ministries, departments and agencies

Ministry of Irrigation, Ministry of Energy and Ministry of Science, Technology and Environment are directly related ministries for use and management of water resources in Nepal. Department of Hydrology and Meteorology (DHM) under the Ministry of Science, Technology and Environment is the authentic organization for weather/flood forecasting in the nation. Since 2010, the DHM has started to give water level including warning level to the public. Ministry of Home Affairs mobilizes police and Ministry of Defense mobilizes army during and after flood disasters. Analyzing the overall activities, it can be concluded that only few works have been based on pre-flood whereas most of the works are concentrated on post flood disasters in the country from the government level.

Flood prone communities

In the recent years, it is noticed that, the flood prone communities are effectively working in IFM. Capacity building, awareness programs, community radio programs etc have significantly contributed in providing knowledge about flood and its impacts to the flood-prone communities. In an education tour at Rautahat district, the author personally found some consensus about future flood in community leader of the flood prone area. I mean, they can guess a probable flood by getting the information about the total amount of rainfall occurred in the upstream area. However, mainly due to poverty, people have not left their settlements from the vulnerable areas including river banks.

Other basin communities

In the context of Nepal, a general awareness is growing up between the main flood-prone communities and communities from other basins that flood hazards can be minimized by IFM. However, concerned agencies of the nation and local communities should promote IFM strategies in broad scale by top-bottom as well as bottom-up approaches.

Scientific and academic institutions

Some reports related to flood are prepared by scientific as well as academic institutions. However, there has not been sufficient involvement of national level scientific and academic institutions in nationwide IFM works. Moreover, active participation of local school teachers is increasing in local level. Some local schools have even kept rain gauges and started to measure rainfall. Such kind of pioneering works conducted at schools become helpful to analyze rainfall and its characteristics among school teachers and students, which ultimately expands to the local societies.

Registered NGOs

Several non-governmental organizations (NGOs) are registered in the national level as well as in the local level in Nepal, among them very few NGOs have focused their works in the management of flood. Most of these NGOs are conducting awareness programs, environmental conservation programs, river cleaning programs and so on. So from the prospective of Nepal more NGOs have to be involved in order to implement IFM in different parts of the country to save people’s lives and properties from the flood induced disasters.

Voluntary organizations

Some of the voluntary groups like mother group *(Aama samuha)* and father group *(Babu samuha)* are actively involved in the natural resource management especially in the mountainous parts of the country. One of the main organizations that have been contributing in the flood induced disaster (FID) from the national as well as local level is Nepal Red Cross Society (NRCS). Not only it has been contributing during and after flood disasters, it has also been contributing to create awareness about the early warnings of flood. Therefore, its works are highly appreciable in disaster management. In a knowledge sharing program of NRCS, this author has participated and found that many volunteers are very eager to know about different types of disasters and their impacts in our societies.

The private sector

Many business houses and individuals have donated large amount of money as well as materials for flood affected communities directly or indirectly. In this sense, their cooperation is found to be in post flood disasters rather than pre-flood conditions. However, mutual cooperation among concerned government agencies, private sectors and expert personals is needed for effective implementation of IFM throughout the country.

CONCLUDING REMARKS

Flood is a multi-dimensional phenomenon. The local communities near by the flood originated areas have to face the severe effects of flood induced disasters. However, in many cases, especially in technical and managerial level, local communities may not be capable for flood management works. Therefore, a community as well as stakeholder involvement is required for the implementation of IFM. It is also necessary to adopt best strategies as structural or non-structural or a combination of both for flood management works. Hence, active participation and cooperation among local communities and different stakeholders should be promoted in order to implement IFM works to reduce flood induced disasters in the country.

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AWARD OF THE HONORARY FELLOWSHIP OF THE NEPAL GEOLOGICAL SOCIETY - 2015

The Nepal Geological Society had conferred upon the Honorary Fellowship of the Nepal Geological Society to Professor Dr. Bishal Nath Upreti, Tribhuvan University, Nepal and Professor Dr. George Mascle, Joseph fourier, University at Grenoble, France on the occasion of Seventh Nepal Geological Congress organized by the Nepal Geological Society on April 2015 in recognition of their contributions towards scientific research and the development of the Himalayan Geology.

Prof. Dr. Bishal Nath Upreti, Nepal

Prof. Bishal Nath Upreti was born in Kavre district, central Nepal on 22 April 1951. He completed his graduate studies from Tribhuvan University (TU), Nepal and then obtained his M. Sc. Degree in geology in 1973 from Karnatak University, India under the Colombo-Plan Scholarship of the government of India. After a brief government service in the Department of Mines and Geology (the then Nepal Geological Survey), he received a Fellowship of Wadia Institute of Himalayan Geology, India for research and obtained his Ph. D in 1980 from M. S. University of Baroda, India. After returning to Nepal, he joined Tribhuvan University in 1979 as a lecture and continued research and teaching until his retirement in early 2014.

In the following years, **Prof. Upreti** was invited to carry out further research and training in institutions and universities in various western countries. He was a DAAD Fellow in Germany (2011), Senior Visiting Professor at IPGP (2009), and Research Fellow at CRPG, CNRS, France (1983), Visiting Professor at Jawaharlal Nehru Centre for Advanced Scientific Research, India (2001), JSPS Fellow and Research Fellow (1983), Japan. This led Prof. Upreti to greatly enlarge the research base as well as develop contacts with collaborative partners in such a wide geographic regions, with whom he has maintained association for decades. He has carried out extensive research in the Nepal Himalaya, published over 70 research papers in national and International peer reviewed journals, and nearly 50 published abstracts are to his credit.

Prof. Upreti is an academician of Nepal Academy of Science and Technology (NAST). He also served as the Dean of the Institute of Science and Technology, Tribhuvan University during (2006-2008). He has attended, chaired and given key note speeches and invited lectures in many national and international seminars and conferences, and universities and institutions; convened international conferences and led research projects. He has written and edited six books, and was the Chief Editor of the Journal of Nepal Geological Society. He is the founder Member, former Secretary, Vice-President and the President of the Nepal Geological Society. He is also the member of other Geological Societies (Geological Society of India, American Geophysical Union, Geological Society of America and IAEG,). He is an Adjunct Professor (2009-2015) at the Queensland University of Technology, Australia, and visiting Professor at the Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China. He is a Fellow of The World Academy of Sciences (TWAS), where

Prof. Dr. Bishal Nath Upreti

so far only three Nepalese have received this honour;. He is also a TWAS Research Professor at the University of Zambia (2012-2017). Professor Upreti is perhaps internationally the best known and respected Nepali geoscientist. He was awarded with national honors such as Gorkha Dakshin Bahu in 1981, Mahendra Vidhya Bhusan medals in 1973 and 1980 (academic awards) and others from the head of the state.

Prof. Upreti has carried out extensive research in the Nepal Himalaya. His contribution on the geological, engineering geological and natural hazard studies cannot be underestimated. He is the founder Secretary of Nepal Centre for Disaster Management (NCDM) and presently the Chairman of Disaster Preparedness Network-Nepal (DPNet-Nepal). Furthermore, he has been actively engaged in the promotion of science and technology education in Nepal through various activities. The recent CBC/National Geographic Channel Intl'/Discovery Science documentary in which Prof. Upreti has acted as the local lead scientist has been a good medium for generating interest in the Himalaya and earthsciences in general. Prof. Upreti was honored with the **AWARD OF THE HONORARY FELLOWSHIP** of the Nepal Geological Society in 2015 AD.

Prof. Dr. Georges Mascle, France

Prof. Georges Mascle was born on Septemper 29, 1937 in Dakar, Senegal. He is Emeritus Professor at Joseph Fourier University at Grenoble, France. He did his double Master in Nature Sciences and Earth Sciences in 1960 from Paris University and also completed Doctorès Sciences (Geology) in 1973 from the same University. From 1962 to 1964, Dr. Mascle was Agrégé Professor in Nature Sciences at the Saint Cloud College, France. He worked in National Service from 1964 to 1966 as Marine Officer first in the Submarine, then as Oceanographer in the French Navy. He became Assistant Professor at the Pierre et Marie Curie (Paris) University (1966–1981) and promoted to Full-Professor at Joseph Fourier University, Grenoble, France in 1981 and served up to 2005.

Prof. Dr. Georges Mascle

Prof. Mascle conducted field researches in diverse areas: the Mediterranean area (Sicily, Sardinia, Provence, Alps, Balearic islands, Algeria, Tunisia, Malta, Cyprus, Albania, Greece, Syria), the Himalaya (Nepal, Ladakh), participated to the 1st French-Chinese mission in Tibet and Western Sierra Nevada (California, Nevada, Oregon). He did many collaborative research programmes: IRD (ORSTOM) in the Andes (Bolivia, Chile, Ecuador, Perù), NATO in Albania, ELF oil company in Oman and in the southern Pyrénées. He participated in numerous marine programmes: Seismic reflexion (Cretan basin, with NO Le Suroit; Ghana - Ivory Coast margin, with NO Jean Charcot; Barbados accretionary complex, with NO L'Atalante; Makran accretionary complex with NO Marion Dufresne), Under sea exploration with submersibles CYANA (North Iberic margin, Ionian Sea, Tyrrhenian Sea) and NAUTILE (Ghana – Ivory Coast margin) and Deep Sea Drilling to the ODP team LEG 107 in the Thyrrenian Sea.

Prof. Mascle supervised 30 thesis and habilitations, and was Director of the CNRS/UJF Grenoble/U Savoie Chambéry Laboratory of Géologie des Chaînes Alpine from 1984 to 1994. He organised various national or international meetings (Sicily field meeting 1967; Grenoble RST18, 1984; Auris HKT6, 1986; Collège de France lectures in Grenoble, 1986; Aussois HKT20, 2004) and reviewed several journals: Académie des Sciences, Société Géologique de France, Geodinamica Acta, Tectonophysics, Nature, Eclogae Geol. Helvetiae, NSF (USA), Fonds National Suisse de la Recherche Scientifique, Arabian Journal of Earth Sciences. He was elected Member of CNRS National committee (Solid Earth) (1995–2000) and became Vice President then President of the French Conseil National des Universités, Section Geology and Paleontology (1987-1995). Prof. Mascle is member of various scientific associations and awarded: Medal Pierre Pruvost of the Société Géologique de France. Prof. Mascle is author and co-author of 230 scientific papers and numerous communications. His special contribution to Himalayan region is G. Mascle, A. Pecher and S. Guillot- Himalaya-Tibet: la collision continentale Inde-Eurasie, 2010, 250 p. (Vuibert-SGF-NGS); English edition in 2012 by Nepal Geological Society (NGS) with the help of S. M. Rai and A. P. Gajurel. He was honored with the **AWARD OF THE HONORARY FELLOWSHIP** of the Nepal Geological Society in 2015 AD.

NEW MEMBERS OF THE NEPAL GEOLOGICAL SOCIETY

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1	LM-718	Jaya Laxmi Sing	Sankhu, Kathmandu	jaya_sin16@yahoo.com
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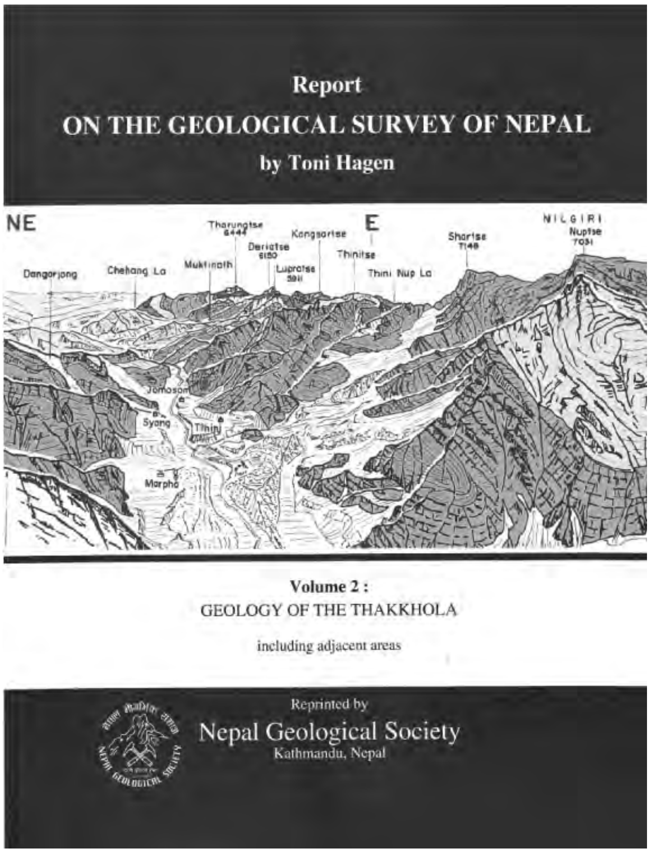
5	LM-722	Yubraj Lamichhane	Gorkha	yrlamichhane7@gmail.com
6	LM-723	Chitra Bikram Tandon	Shantinagar -01, Dang	cbtandon33@gmail.com
7	LM-724	Ashim Rijal	Angsarang-1, Panchthar	rijalashim@gmail.com
8	LM-725	Santosh Adhikari	Dept. Geology, Tri-Chandra Campus	214@yahoo.com
9	LM-726	Subeg Bijukchhen	Bhaktapur, Kathmandu	subeg@eng.hokudai.ac.jp
10	LM-727	Indira Siwakoti	Dhumbarai Kathmandu	ishiwakoti@yahoo.com
11	LM-728	Rajendra Acharya	Sahare 5, Dolakha	geo64@yahoo.com
12	LM-729	Deepak Prasad Adhikari	Australia	deepak.adhikary@csiro.au
13	M-730	Suman Manandhar	Naya 4, Naya Naikap, Kathmandu	schumanmail@gmail.com

NEW BOOKS



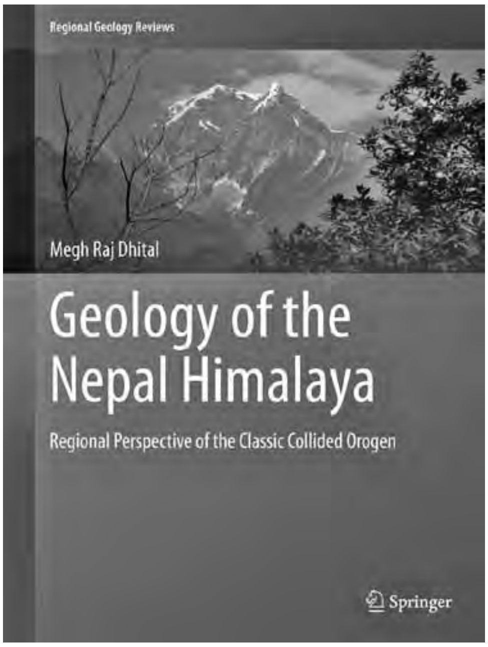
Report ON THE GEOLOGICAL SURVEY OF NEPAL
By Dr. Toni Hagen (1969)
Volume II: GEOLOGY OF THE THAKKHOLA
including adjacent areas
Reprint 2014

The Report on the "Geological Survey of Nepal: Geology of the Thakkhola" was published by late Dr. Toni Hagen in 1969. The report mainly covers the geology of the northern part of Kali Gandaki and Marshyangdi valleys in mid-western Nepal, and primarily focusses on the Tethyan Himalayan terrain of Thakkhola, Manang and eastern Dolpo regions. With a large number of cross-sections and excellent sketches and a geological map produced in colour, the report encompasses a fairly detailed stratigraphic and paleontological work on the fossiliferous Tethyan sequences. This was the first comprehensive geological report of this extremely remote and forbiddingly difficult terrain, and even today remains one of the detailed geological works so far carried out in this part of the country.

Dr. Toni Hagen was first to introduce these famous high mountain valleys of Thakkhola-Mustang (Kali Gandaki River section), Manang (Marsyangdi River section) and Dolpo and opened up the way to the outside world that has now become the world famous and prime geologic and tourist destinations in Nepal.

Dr. Katrin Hagen, Toni Hagen's eldest daughter, kindly provided copyright to Nepal Geological Society to reproduce this highly valuable report. Dr. Katrin Hagen also provided some rare photographs taken by her father which are included as addendum at the end of the reprinted book. Nepal Geological Society believes that the report will greatly benefit all researchers and students who are actively engaged or have interest in the Himalayan geoscience research.

Professor Bishal Nath Upreti, life member and former President of Nepal Geological Society took all the initiatives and worked hard to reproduce this book on behalf of Nepal Geological Society.



Geology of the Nepal Himalaya
Regional Perspective of the Classic Collided Orogen
Author: Megh Raj Dhital

2015, XXIV, 498 p., 304 illus., 107 illus in colour, Hardcover
ISBN 978-3-319-02495-0
http://www.springer.com/978-3-319-02495-0

This book comprehensively covers the classic continent-continent collision zone at the very heart of the Himalaya. It addresses the geology of the entire Himalayan range in Nepal, i.e., from the Gangetic plain in the south to the Tethyan zone in the north. Without a comprehensive look at the various Himalayan zones, it is practically impossible to fully grasp the processes at work behind the formation and development of the spectacular Himalaya. However, the goal is not merely to document all the scientific ontology but rather to reveal a sound basis for the prevailing concepts. Both the early literature on Himalayan geology and contemporary trends are fully covered. For the first time, the origin, use, and abuse of common Himalayan geological terms such as the Siwaliks, Lesser Himalaya, Main Boundary Thrust, Main Central Thrust, and Tethys are discussed. The book will help readers to progress from a cognitive approach to a constructive one by linking various types of knowledge, such as seeking relations between various geological structures as well as between earlier thoughts or views and contemporary approaches.

Though many writers have chosen to discuss the geology of the Himalaya from south to north, this book is arranged somewhat differently. It is because, the limits of various broad geological divisions are not always distinct, and it is desirable to follow the geological convention of dealing with the oldest units first. Hence, after giving introduction to the Himalaya and neighbouring regions, the book describes the oldest sequence of the Lesser Himalaya, and it is followed by the Higher Himalaya, Tethys Himalaya, Siwaliks, and the youngest Terai and intermontane basins.

This book comprises 7 sections and 36 chapters. Chapter 1 provides the introduction, featuring general background to the Himalaya, including its origin, extent, and global tectonic context. Section I (Chapters 2 and 3) is devoted to the geological setting of the Himalaya and physiography of Nepal, whereas Section II (Chapters 4 and 5) deals respectively with the northwest and southeast neighbouring tracts. Section III (Chapters 6 to 12) describes the Lesser Himalaya in its diversity of lithology, stratigraphy, and structure. Section IV (Chapters 13 to 20) discusses the Higher Himalayan rocks with their rather vague stratigraphy and intense metamorphism. The last chapter of this section deals with various metamorphic models explaining the inverted metamorphism in the Himalaya. Section V (Chapters 21 to 26) is devoted to the Tethys Himalaya where stratigraphy is clearer owing to the occurrence of fossils, but this belt also experienced severe deformation, manifested by intricate folds and faults. The Siwalik belt, characterised by its relatively simple lithology and spectacular sedimentary structures, is presented in Section VI (Chapters 27 to 33). This zone has also undergone significant compression and shortening, as revealed by many folds and imbricate thrusts. Section VII (Chapters 34 and 35) deals with the geology of the Terai and a few intermontane basins. Neotectonics and active faults are also described in this section. Conclusions are given in Chapter 36, where the main geological aspects of Nepal are summarised. In this chapter, the Nepal Himalaya is also compared and contrasted with other parts of the orogen.

CONGRATULATIONS

Nepal Geological Society extends its heartiest congratulations to the following members of the Society for their achievements (Promotions, Awards, New Jobs etc.)

PROMOTIONS

Mr. Dilip Kumar Sadaula

Promoted to Superintending Engineering Geologist (Class I), Department of Electricity Development (DoED), Anamnagar, Kathmandu, Nepal
Date of Promotion: 2071-10-23

Project Chief, Pancheshwar Multipurpose Project (2071-12-04).
Executive Director (Environment), Pancheshwar Development Authority (PDA) (2072-2-27).

Ms. Monika Jha

Promoted to Senior Divisionl Geologist (Class II), Department of mines & Geology, Lainchaur, Kathmandu, Kathmandu, Nepal

Date of Promotion: 2072-01-10

Ajab Singh Mahara

Promoted from Deputy Manager to Manager, Nepal Electricity Authority (NEA), Nepal

Date of Promotion: 2071/08/14

Krishna Bahadur Basnet

Promoted from Assistant Manager (level 8) to Deputy Manager (level 9), Nepal Electricity Authority (NEA), Nepal

Date of Promotion: 2071/08/14

Madan Raj Pokharel

Promoted from geologist 7th level to 8th level (assistant manager), Soil, rock and concrete laboratory, NEA, Kathmandu, Nepal

Date of Promotion: 2071-08-16

Sunil Raj Paudel

Promoted from geologist 7th level to 8th level (assistant manager), Soil, rock and concrete laboratory, NEA, Kathmandu, Nepal

Date of Promotion: 2071-08-16

AWARDS

Ph. D. AWARDS

Dr. Upendra Baral

Institute: Institute of Tibetan Plateau Research, University of Chinese Academy of Sciences
Research Title : Provenance of Tertiary Foreland Basin in Nepal Himalaya
Year of Graduation 2015

APPOINTMENT

Mr. Narendra Dhoj Maskey

Rre-elected for second three year terms (1 July, 2014 to 30 June, 2017) as East West Center Association (EWCA) Executive Board "MEMBER" and East West Center Association (EWCA) Executive Board "CHAIR". EWCA Executive Board Functions from Honolulu Hawaii, USA.

Dr. Basanta Raj Adhikari

Assistant Professor, Department of Civil Engineering, Institute of Engineering (IOE), Central Campus, Pulchowk, Tribhuvan University, Nepal appointed as Deputy Director, Center for Disaster Studies (IOE, TU)
Appointment date: 2072-2-18

NEW JOB ENTRY

नेपाल इन्जिनियरिङ सेवा, जियोलोजी समूह, जनरल जियोलोजी उपसमूह, राजपत्रांकित तृतिय श्रेणी (प्रा.), जि.फी./रि.अ., खानि तथा भूगर्भ विभाग, उद्योग मन्त्रालय अन्तर्गत

सि.नं.	नाम	पद	सिफरिश मिति	नियुक्ति मिति
१	श्री नारायण अधिकारी	रि.अ. (जि.)	२०७१/५/१५	२०७१/५/१६
२	श्री सुस्मिता भण्डारी	जि.फी.	२०७१/५/१५	२०७१/५/१६
३	श्री कविता कार्की	रि.अ. (जि.)	२०७१/५/१५	२०७१/५/१६

4. **Dr. Ashok Sigdel**, Geologist, Nepal Electricity Authority, Soil, Rock and Concrete Laboratory, Swayambhu, Kathmandu, Nepal
5. **Mr. Binod Maharjun**, Geologist, Nepal Electricity Authority, Soil, Rock and Concrete Laboratory, Swayambhu, Kathmandu, Nepal
6. **Mrs. Indira Shiwakoti**, Geologist, Nepal Electricity Authority, Soil, Rock and Concrete Laboratory, Swayambhu, Kathmandu, Nepal

LIST OF BOOKS PUBLISHED BY THE NGS

1. The Himalaya-Tibet Collision, 2013

Georges Mascle, Arnaud Pêcher Stéphane Guillot, Santa Man Rai & Ananta P. Gajurel
Preface By Patrick Le Fort

Nepal Geological Society, Sociétê Géologique De France Vuibert

2. Report on The Geological Survey of Nepal

By Toni Hagen

Volume I: PRELIMINARY RECONNAISSANCE Attached Plates 1969

Reprinted by Nepal Geological Society, Kathmandu, Nepal, 2013

3. Report on The Geological Survey of Nepal

By Toni Hagen

Volume II: GEOLOGY OF THE THAKKHOLA including adjacent areas

Reprinted by Nepal Geological Society, Kathmandu, Nepal, 2014

LIST OF PUBLISHED JOURNALS OF NEPAL GEOLOGICAL SOCIETY

1. Journal of Nepal Geological Society, Vol. 48, 2015, Speical issue, abstract of the 7th Nepal Gelogy Congress
2. Journal of Nepal Geological Society, Vol. 47, 2014
3. Journal of Nepal Geological Society, Vol. 46, 2013
4. Journal of Nepal Geological Society, Vol. 45, Speical issue, abstract of the 27th HKTW 2012
5. Journal of Nepal Geological Society, Vol. 44, 2012
6. Journal of Nepal Geological Society, Vol. 42, 2011
7. Journal of Nepal Geological Society (Abstract of Sixth Nepal Geological Congresss on Geology, Natural Resources, Infrastructure, Climate Change and Natural Disasters, 15-17 November 2010, Vol. 41 (Special isssue), November, 2010
8. Journal of Nepal Geological Society, Vol. 39, June 2009
9. Journal of Nepal Geological Society (Proceedings of International Workshop on Seismology, Seismotectonics, and Seismic Hazard in Nepal Himalaya, 28–29 November 2006 and Fifth Nepal Geological Congress on Geology, Environment, and Natural Hazards Mitigation: Key to National Development, 26–27 November 2007), Vol. 38 (Special Issue), December 2008
10. Journal of Nepal Geological Society, Vol. 37, June 2008
11. Journal of Nepal Geological Society (Abstracts of Fifth Nepal Geological Congress on Geology, Environment, and Natural Hazards Mitigation: Key to National Development, 26–27 November 2007), Vol. 36 (Special Issue), November 2007
12. Journal of Nepal Geological Society, Vol. 35, June 2007
13. Journal of Nepal Geological Society (Proceedings of Fifth Asian Regional Conference on Engineering
14. Geology for Major Infrastructure Development and Natural Hazards Mitigation, 28–30 September 2005),
15. Vol. 34 (Special Issue), December 2006
16. Journal of Nepal Geological Society, Vol. 33, June 2006
17. Journal of Nepal Geological Society (Abstracts of Fifth Asian Regional Conference on Engineering Geology for Major Infrastructure Development and Natural Hazards Mitigation, 28–30 September 2005), Vol. 32 (Special Issue), September 2005
18. Journal of Nepal Geological Society, Vol. 31, June 2005
19. Journal of Nepal Geological Society (Proceedings of Fourth Nepal Geological Congress, 9–11 April 2004), Vol. 30 (Special Issue), December 2004

20. Journal of Nepal Geological Society, Vol. 29, June 2004
21. Journal of Nepal Geological Society, Vol. 28, June 2003
22. Journal of Nepal Geological Society (Proceedings of Third Nepal Geological Congress, 26–28 September 2001, Kathmandu, Nepal), Vol. 27 (Special Issue), December 2002
23. Journal of Nepal Geological Society, Vol. 26, June 2002
24. Journal of Nepal Geological Society (Proceedings of Workshop on the Himalayan Uplift and Palaeoclimatic Changes in Central Nepal, 10 November 2000), Vol. 25 (Special Issue), December 2001
25. Journal of Nepal Geological Society (Abstract Volume of Third Nepal Geological Congress, 26–28 September 2001), Vol. 24 (Special Issue), September 2001,
26. Journal of Nepal Geological Society, Vol. 23, June 2001
27. Journal of Nepal Geological Society (Proceedings of International Symposium on Engineering Geology, Hydrogeology, and Natural Disaster with Emphasis on Asia, 28–30 September 1999, Kathmandu, Nepal),
28. Vol. 22 (Special Issue), December 2000
29. Journal of Nepal Geological Society, Vol. 21, June 2000
30. Journal of Nepal Geological Society (Abstract Volume of International Symposium on Engineering Geology, Hydrogeology, and Natural Disaster with Emphasis on Asia, 28–30 September 1999, Kathmandu, Nepal), Vol. 20 (Special Issue), 1999
31. Journal of Nepal Geological Society, Vol. 19, 1999
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भूकम्पीय सुरक्षाका लागि

घुँडा टेकी, गुडुल्की, ओत लागी समात !
Duck, Cover and Hold on

गुडुल्किनु (Duck)	ओत लाग्नु (Cover)	ओतलाई समात्नु (Hold on)
गुँडुल्किनु (Duck) भनेको घुँडा टेकेर घोप्टो परी, गुडुल्किएर हाँसले झैं टाउको लुकाउँदै आफ्नो शरीरको आयतनलाई सकभर सानो बनाउनु हो ।	घोप्टिएर घुँडा टेकी बस्दा टाउको र मेरुदण्ड जोगाउन कुनै टेबल जस्तो बलियो सामग्रीको ओत लागी उछिट्टिएर आएका वा खसेका वस्तुहरुबाट बच्नु हो ।	भुईंचालोको बेला ओत दिने वस्तु वा आफु नै हुत्तिनुबाट जोगिन ओतलाई बलियो गरी समात्नु हो ।

विद्यालयमा "Duck, Cover & Hold on" को अभ्यास गर्ने प्रक्रिया

क. संकेत - १ विद्यालयमा तोकिएको व्यक्तिले एक मिनेट सम्म घण्टी बजाउने

ख. जवाफी कार्य - कक्षा कोठामा वा अन्य कोठामा भएका सम्पूर्ण शिक्षक तथा विद्यार्थीहरुले संकेत रहँदासम्म गुडुल्किएर बस्ने (चित्र क) ।

ग. संकेत - २ पुनः शिक्षकले २ घण्टी बजाउने । त्यसपछि पहिले नै पहिचान गरिएको सुरक्षित स्थान तर्फ नहड्बडाइकन लाईन लगाएर जाने (चित्र ख) ।

घ. भेला गर्ने - स्थानान्तरण कार्य समाप्त भएपछि सम्पूर्ण शिक्षक तथा विद्यार्थीहरु सुरक्षित स्थानमा भेला हुने ।

ङ. गन्ती गर्ने - विद्यार्थीहरुलाई पूर्वनिर्धारित स्थानमा कक्षागत रुपमा लाईन लगाई गन्ती गर्ने र हाजिरी रुजु गर्ने ।

च. खोजी - हाजिरी रुजु गर्दा नभेटिएका विद्यार्थीहरुलाई सम्भावित स्थानहरुमा आफ्नो सुरक्षाको ख्याल गर्दै खोजी गर्ने ।

छ. उद्धार - सुरक्षित तवरले घाइतेहरुलाई तालिम प्राप्त विद्यार्थी स्वयंसेवीहरुद्वारा उद्धार गरी प्राथमिक उपचार गर्ने (चित्र ग)। सिकिस्त घाइतेहरुलाई छिटो सुरक्षित तवरबाट अस्पताल पुऱ्याउने ।

चित्र क - घुँडा टेकेर घोप्टिई, गुडुल्किएर टाउको जोगाउँदै

चित्र ख - विद्यार्थीहरु सुरक्षित स्थान तर्फ जान विद्यालय भवनबाट बाहिरिँदै

चित्र ग - प्राथमिक उपचार गरिँदै

यही प्रकृयालाई अन्य संस्थाहरुमा समेत प्रयोग गर्न सकिन्छ ।

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